Publication 366

CIB W115 Green Design Conference

Sarajevo, Bosnia and Herzegovina 27 - 30 September 2012

International Council
for Research and Innovation
in Building and Construction

International Council for Research and Innovation in Building and Construction

Conference Proceedings
of CIB W115 Green Design Conference
Sarajevo, Bosnia and Herzegovina 27-30 September 2012

Edited by
Elma Durmisevic
Adnan Pasic

Published by International Council for Research and Innovation in Building and Construction (CIB), Working Commission W115 and the University of Twente, the Netherlands, Sarajevo Green Design Foundation Bosnia and Herzegovina

September 2012
ISBN: 978-90-365-3451-2

Conference organization committee
Chair: Elma Durmisevic, University of Twente (NL)
Chair: Adnan Pasic, University of Sarajevo (BH)
Co chair: Adnan Salihbegovic, University of Sarajevo (BH)
Co chair: Boran Pikula, University of Sarajevo (BH)
Co chair: Nirvana Pistoljevic, Columbia Univerity (USA)
Assistant: Elma Avdić (BH)
Assistant: Stefan Binnemars (NL)
Assistant: Jasmina Koluh (BH)
Assistant: Mirjan Mehmedinović (BH)
Assistant: Tjark van de Merwe (NL)
Assistant: Sajdin Osmancevic (BH)

Steering Committee
Chair: Elma Durmišević, University of Twente (NL)
Chair: Adnan Pašić, University of Sarajevo (BH)
Abdol Chini, University of Florida (USA)
Frank Schultmann, Karlsruhe Institute of Technology (GE)
John Storey, Victoria University of Wellington (NZ)
Fred Houten, University of Twente (NL)
Wim Bakens, CIB (NL)
Martin Wollensak, University of Wismar (GE)
Maarten Steinbuch, Technical University of Eindhoven (NL)
Rikus Eising, University of Twente (NL)
Joop Halman, University of Twente (NL)
Faruk Čaklovica, University of Sarajevo (BH)
Denis Zvizdić, University of Sarajevo (BH)
Rada Cahtarević, University of Sarajevo (BH)
Ejub Džaferović, University of Sarajevo (BH)
Mustafa Hrasnica, University of Sarajevo (BH)

Scientific committee
Chimay Anumba, Pann State University, (USA)
Hazim Bašić, University of Sarajevo (BH)
Thomas Bednar, Vienna Univerity (AU)
Dženana Bijedić, University of Sarajevo (BH)
Faruk Caklovica (BH)
Abdol Chini, University of Florida(USA)
Birgul Colakoglu, Yildiz University (TU)
Ype Cuperus, Delft Technical University, (NL)
Adnan Delić, University of Sarajevo (BH)
Samir Dolarevic, University of Sarajevo (BH)
Sanja Durmišević TNO (NL)
Elma Durmišević, University of Twente (NL)
Bram Entrop, University of Twente (NL)
Mark Gorgolewski, Ryerson University, Toronto, Canada (CA)
Ahmed Hadrović, University of Sarajevo (BH)

Joop Halman, University of Twente (NL)
Vesna Hercegovac Pašić, University of Sarajevo (BH)
Gilli Hobbs, BRE (UK)
Srđa Hrisafović, University of Sarajevo (BH)
Charles Kibert, University of Florida, (USA)
Azra Korjenic, Vienna University of Technology (BH)
Azra Kurtović, University of Sarajevo (BH)
Jos Lichtenberg, University of Eindhoven (NL)
Eldin Mehić, University of Sarajevo (BH)
Esad Mešić, University of Sarajevo (BH)
Slađa Miljanović, University of Sarajevo (BH)
Ljubo Miscevic, University of Zagreb (HR)
Nermina Mujezinović, University of Sarajevo (BH)
Esad Mulavdić, University of Sarajevo (BH)
Shiro Nakajima, Building Research Institute, (JP)
Aleksandra Nikolic (BH)
Adnan Pasic, University of Sarajevo (BH)
Amir Pašić, University of Sarajevo (BH)
Nataša Perković, University of Sarajevo (BH)
Boran Pikula , University of Sarajevo (BH)
Nirvana Pistoljevic, Columbia Univerity (USA)
Wim Poelman, University of Twente (NL)
Angele Reinders, University of Twente (NL)
Job Roos, Delft Technical University, (NL)
Adnan Salihbegović, University of Sarajevo (BH)
Amira Salihbegović, University of Sarajevo (BH)
Frank Schultmann, Karlsruhe Institute of Technology, (GE)
Amra Serdarević, University of Sarajevo (BH)
Jessica Singer Dudek, Columbia University (USA)
Martin Smit, Univerity of Delft (NL)
Maarten Steinbuch, Technical University of Eindhoven (NL)
Irina Stipanovic (NL)
John Storey, Victoria University of Wellington, (NZ)
Aleksandra Stupar, University of Belgrade (SR)
Kaoru Suehiro, Kyushu University (JP)
Catarina Thormark TU (SE)
Nina Ugljen, University of Sarajevo (BH)
Holger Wallbaum, ETH Zürich, Switzerland (SW)
Martin Wollensak, University of Wismar (GE)
Simos Yannas, AASA, (UK)
Ervin Zecevic, University of Sarajevo (BH)
Aida Zgonić-Idrizbegović, University of Sarajevo (BH)
Tadeja Zupančič, Ljubljana, (SL)

TABLE OF CONTENT

MOBILITY AND GREEN CITY

Interplay of internet of things, cloud computing and sensor networks in design of future smart and green cities

Adnan Salihbegovic
University of Sarajevo Bosnia and Herzegovina

Intermodal (re) development between green logistics and intelligence environment / green strategy the new intermodal shape in case of Sagrera, Sant Marti and Verneda – Barcelona

Vladimir Savcic
Polytechnic University of Catalonia, Spain

Assessing the overall life cycle impact of home energy management systems

S.S. van Dam
Delft University of Technology, The Netherlands

Energy efficient LED Lighting of the Historic city centre of Sarajevo

Srdja Hrisafovic
University of Sarajevo Bosnia and Herzegovina

A study on energy and water management in green infill solutions and ground floor additions

Jacopo Gaspari, Elena Giacomello
University of Bologna, Iuav University of Venice, Italy

GREEN CITY AND ECONOMY

Going Green - How to Change the Rural in Order to Sustain the Urban

Ivan Simic, Aleksandra Stupar, Zoran Nikezic
University of Belgrade, Serbia

Assessment of fuel economy improvement potential for a hydraulic hybrid transit bus

Predrag Mrdja, Marko Kitanovic, Slobodan J. Popovic, Nenad Miljic, Vladimir Petrovic
University of Belgrade, Serbia

Performance oriented building assessment: time and space the two dimensions of sustainability

Carmen Gargiulo
Politecnico di Milano, Italy

Ensuring social cohesion – Citizens as planners of urban green spaces

Dženan Bećirović, Amila Brajić, Bruno Marić, Senka Mutabdžija
University of Sarajevo, Bosnia and Herzegovina

MOBILITY

Analysis and evaluation of the recycling system of motor vehicles at the end of the life cycle in Bosnia and Herzegovina

Lejla Dacić, Samed Ormanović
University of Sarajevo, Bosnia and Herzegovina

Comparison of dynamic characteristics of electric and conventional road vehicles

Semir Beganović, Suada Dacić
University of Sarajevo, Bosnia and Herzegovina

Analysis of Ecological Benefits of Urban Cycling in Sarajevo
Damir Margeta
Auto Ceste Bosnia and Herzegovina

Jerusalem: the holz sities – cultural transformation and continuity
Gil Peled
University of Twente, The Netherlands

How Behavioral can help us become more green
Nirvana Pistoljević
Teachers Collage, Columbija University, USA

Justification of Electric and Hybrid Vehicle Use in Urban Areas
Boran Pikula
University of Sarajevo Bosnia and Herzegovina

Public Faucets in Bosnia ana Herzegovina
Ahmet Hadrovic
University of Sarajevo Bosnia and Herzegovina

Understanding Human Behavior in Designing Building-Scale Sustainable Ecosystems
Mirsad Hadzikadic
University of North Carolina at Charlotte, United States of America

Preface

University of Sarajevo and Green Design Foundation housed the CIB W115 conference on Green Design Conference 27-30 September 2012, organized in cooperation with University of Twente in Enschede, the Netherlands.
Unique feature of the conference was its attempt to bring together scientist from different fields and involve them in multidisciplinary debate during the evening key not addresses and discussions.
Innovation in sustainable construction has been presented through number of case studies by the industry members of the different countries.
The emphasis of the conference was on innovative design and construction methods and assessment methods that will incorporate effective use of materials into the whole life cycle of buildings and building materials. Besides new energy concepts and mobility strategies were presented through couple of case studies.
Eight different conference themes have been presented during the four day being:

1. Green Materials and Technologies covering issues of waste materials as source for new products, methods for effective material recovery
2. Social Cohesion and Cultural Continuity
3. Mobility and Infrastructure
4. Energy solutions
5. Urban Landscaping and farming
6. Green Buildings
7. Green Cities
8. Economy, Policy and regulatory standards that can stimulate development and implementation of green concepts and techniques

The conventional way of construction has become a burden to the dynamic and changing society of the 21st century. Developers and real estate managers warn that there is a miss-match between the existing building stock and the dynamic and changing demands with respect to the use of buildings and their systems.
A report by the World Resource Institute projects 300% rise in material use as world population and economic activity increases over the next 50 years. Steel price is rising. Raw materials are gradually diminishing and becoming expensive, landfill sites are filling up forcing disposal fees to increase and making the waste management exceptionally expensive.

The physical impact of increasing building mass in industrialized nations and developing world has become undeniable in 21st century. The appetite for raw materials and landfill sites, as well as acceleration of the changing demands by users clearly indicates that a fundamental change in the way buildings are designed and constructed is needed.

During the conference the state of the art papers have been presented with respect to innovative approach to design, construction and management of buildings, building materials and cities.
This subject integrates issues from city planning and infrastructure to spatial adaptability and flexibility of building systems to material efficiency and energy saving (embodied energy).
Development of the research agenda with respect to this topic deal with issues such as, life cycle performance and strategies, design methodology, systems development, reuse, renewable materials, cad manufacturing, and development of performance measurement tools (transformation capacity measurement tool, life cycle costing, life cycle assessments etc.).

Background on CIB W115
This CIB W115 Commission on Construction Material Stewardship aims to:

• Drastically reduce the deployment and consumption of new non-renewable construction materials, to replace nonrenewable materials with renewable ones whenever possible, to achieve equilibrium in the demand and supply of renewable materials and ultimately to restore the renewable resource base
• Carry out these tasks in ways to maximize positive financial, social and environmental and ecological sustainability effects, impacts and outcomes.

Dr. Elma Durmisevic

Assessing levels of Deconstruction and Recyclability

G.Hobbs[1], K. Adams[1]
[1]BRE (Building Research Establishment), UK

Abstract
Designing for deconstruction and recycling enables resources to be reused in the most efficient and productive way. This is particularly important looking into the future as we move away from traditional construction methods and materials to more composite structures. There is no standard, test or guidance in place that designers or clients can use to assess the ease of deconstruction and subsequent recyclability. Lack of measurement or assessment methods makes it very difficult to measure success until the building is demolished. A recently started project, to develop design for deconstruction criteria to initially evaluate ease of deconstruction and recovery, is the focus of this paper.

Keywords:
Design for deconstruction, Design for recycling, Design for reuse, demolition, Pre-demolition audit

1 INTRODUCTION

Designing for deconstruction (DfD) and recycling enables resources to be reused in the most efficient and productive way when the building is eventually demolished. This is very different from maximising recycling and recovery of existing buildings using the latest demolition or recycling technologies which has tended to be the focus when considering resource efficiency and demolition. There are a number of ways to potentially promote DfD, including the provision of credits in green building standards such as BREEAM (BRE Environmental Assessment Methodology). However, until it is possible to assess the design of a building, in terms of ease of deconstruction, reuse and recycling, it will be impossible to compare the future deconstructability of these designs and award credits on that basis.

BRE have recently started a project, funded by the BRE Trust and Zero Waste Scotland, to develop design for deconstruction criteria that could be used to evaluate ease of deconstruction, reuse and recycling, focussing on housing in the first instance. The first task of the project is nearing completion and relates to reviewing existing work in this area. Some of the findings of this task are presented in this paper.

2 BACKGROUND

A recently completed BRE Trust project called *Dealing with Difficult Demolition Wastes* revealed that the high recycling rates currently achieved by the demolition sector would decline unless the buildings being designed today were easier to take apart. Waste from construction, demolition and excavation represents the largest waste stream in the UK at an estimated 87 million tonnes in 2008. Of this, at least 21 million tonnes is inert waste from demolition [1], such as concrete, bricks and soils. Virtually all of this material is currently reused or recycled either on the same site in the follow on construction, or taken off site for reuse and recycling elsewhere. Similarly, other demolition waste types, such as solid timber, tend to be reused or recycled. All of this leads to high diversion from landfill rates for demolition waste, typically over 90%. However, there is growing concern in the demolition sector that it may not be possible to improve, or maintain, these high recycling rates into the future due to the increasing prevalence of difficult demolition waste.

These wastes are termed ‘difficult’ as they may be problematic to recover, which could be due to their material composition, techniques of demolition/strip-out, contamination, or their low value, and as a result they are likely to end up in landfill. Some may also have relatively high environmental impact, due to their hazardous qualities, high embodied energy or global warming potential, so the inability to recover these products at the end of their life increases their overall effect on the environment.

Many of these issues arise from the decisions made in the design and construction of buildings. Since we cannot guarantee that new technologies will be developed to revolutionise demolition into the future, there should be a focus today on trying to avoid waste related legacies into the future and on actively considering ways in which building components and materials can be put together to facilitate future reuse and recycling. These objectives are the basis of DfD.

3 DRIVERS AND BARRIERS TO DFD

3.1 Drivers for DfD

- *Environmental driver:* Reducing extraction of new materials, reducing materials sent to landfill.
- *Socio-economic driver*: Employment: jobs may be lost in primary manufacturing, but some will be created in the refurbishment of equipment and in the processing of reclaimed materials; social benefits: benefits from reduced loss of land due to materials extraction and landfill sites.
- *Commercial driver*: Landfill tax introduced on 1st October 1996 in the UK is an incentive to deconstruct (annual rise of £8/tonne; currently at £64/tonne for non-inert waste); Aggregate Levy: £2.50/tonne which provides an incentive to use recycled goods and materials.
- *Political drivers:* Government policy on sustainability (minimisation of wastes, maximisation of recycled and reclaimed materials); Key policies include the joint English industry/Government target to halve Construction, Demolition and Excavation (C,D&E) waste landfilled by 2012 based on a 2008 baseline (equating to an extra 6.3 million tonnes of waste being diverted from landfill each year) and CEN TC350 Sustainability of Construction Works – this standard relates to construction products and may include end-of-life recyclability indicators; however there are many other political drivers.
- *Risk management:* Legislation, health and safety, fiscal measures encouraging minimisation of primary materials extraction and waste generation; reclassification of materials and wastes: potential

reuse of material after the life of the project needs to be thought through; producer responsibility/liability.

- *Economic reasons for using design for deconstruction:* The economic drivers include increasing the flexible use and adaptation of property at a minimal future cost, reducing the whole-life environmental impact of a project and reducing the quantity of materials going to landfill.

3.2 Barriers to DfD

- *Lack of legislation*: no legislation exists in the UK that requires client or contractors to consider deconstruction at the design stage.
- *Human barrier:* it is easier for people to carry on doing what they have always done and people tend to prefer new materials to second hand ones.
- *Additional design cost*
- *Procurement and contractual responsibilities*
- *Technical barrier*: jointing systems, for example between pre-cast concrete beams, are usually stronger than the actual beam and are very difficult to deconstruct.
- *Economic barrier*: cost of individual units (tiles, paving slabs etc) is usually low, so it is more cost effective to buy new ones.
- *Dimensional barrier*: usually structural units (beams, columns, etc) are for one-off bespoke structures with unique dimensions.
- *Physical barriers*: pre- and post-tensioned beam/ floors, jointing systems, natural ageing of concrete, reinforcement corrosion, presence of coatings.
- *Contamination and aesthetics of components issues*: contamination with pollutants (petrol, grease, grime)
- *Perception and education:* perception that composite and strongly bonded elements are more durable and stronger structurally. In reality, a well designed building that incorporates design for deconstruction elements should pose no increased risk of structural failure.
- *Problem of storage and double-handling of materials:* movement between sites can increase costs of reuse
- Lack of markets for reusable elements or components.

4 DESIGN STAGES

The level of detail in relation to DfD will depend upon the stage of design. Ideally the commitment to embed DfD will be set from the very early stages of a client selecting a designer, to ensure the appointed designers are willing and able to incorporate DfD into the design process. *The Environmental Design Pocketbook* [2] suggests that DfD should be considered at the following (RIBA) stages:

- <u>Work stage C: Outline proposals/concept</u>

Commit to designing for deconstruction

- <u>Work stages E,F: technical design and production information</u>

Detail for deconstruction

- <u>Work stage L: post-practical completion</u>

Undertake a deconstruction drawing and logbook, to include audit of building material standards and reclamation potential

This guide also provides a checklist of issues to consider in terms of DfD, including issues such as undertaking a health and safety assessment of the proposed deconstruction strategies in accordance with Construction Design and Management (CDM) Regulations.

5 DESIGN CONSIDERATIONS FOR DFD

At the simplest level, there tends to be two main considerations, firstly the materials and components used; secondly, the way in which they are put together (and thus able to be taken apart). It then gets a lot more complicated in terms of specific design and material selection decisions that will have a positive or negative effect. In the UK, there are a number of guidance documents that can help the designer and build team identify what could be done to facilitate DfD.

A CIRIA report on *Principles of design for deconstruction to facilitate reuse and recycling* is one such report [3]. This provides advice by building element, along with multiple case studies to illustrate particular points. In terms of developing criteria for the products and materials selected, this report provides an excellent overview for each building element, in terms of:

- Steps to maximise value at deconstruction
- Design for reuse after deconstruction
- Design for recycling after deconstruction

It also combines information from the Sassi 2002 report (see section 6 for more detail on this report) on the ratings developed for different specifications relating to the building element type, where they were available. For example, when considering the building envelope, an evaluation is provided for curtain walling, stone cladding, concrete, GRP cladding, windows, metal sheeting, and roof coverings. Additional rating information from the Sassi 2002 report is also provided for different external wall specifications. If this approach is followed to its logical conclusion, in that the generic design choices for each element are evaluated, followed by a finessing for each specification, a robust assessment process for the overall design could be developed. What is less clear is how much additional data will need to be collected to have a complete dataset and the time that might be needed to carry out a DfD assessment using such a dataset.

SEDA [4] produced a detailed guide to *Designing for Deconstruction* that can be downloaded free of charge. The guide examines the context and principles of designing for deconstruction and then focuses on five typical construction details compared with alternatives which optimise the potential for each detail to exploit deconstruction and waste reduction techniques, along with explanations and costs. Some of the 'quick wins' for deconstruction are summarised here:

- Nails and bolts have appropriate uses as per the type of connection and size of the members. A variety of nails in one building causes the requirement for multiple tools for removal. A mix of bolts, screws, nails requires constant shifting from one tool to the next. Fewer connectors and consolidation of the types and sizes of connectors will reduce the need for multiple tools and constant change from one tool to the next.

- Long spans and post and beam construction reduce interior structural elements and allow for structural stability when removing partitions and envelope elements.
- Doubling and tripling the functions that a single component performs will help “dematerialize” the building in general and reduce the problem of layering of materials.
- Separating long-lived components from short-lived components will facilitate adaptation and reduce the complexity of deconstruction, whereby types of materials can be removed one at a time, facilitating the collection process for reuse/recycling.
- Lightweight materials and lightweight structures reduce the stresses on the lower portions of the building and reduce the need for work at height and use of equipment.
- Simple consolidation of plumbing service points within a building not only has the benefit of reducing the length of lines, but it also reduces the points of entanglement and conflict with other elements such as walls and ceilings/roofs.
- Separating the plane of the top and bottom of the wall from the plane of the floor structure facilitates mechanical separation and structural stability during the deconstruction process. Precast concrete floor panels act in this manner.

Building heavily upon the SEDA report, a US publication [5] produced a simplified ‘10 key principles’ for Design for Disassembly. These are summarised as:

1. Document materials and methods for deconstruction
2. Select high quality materials
3. Design connections that are accessible.
4. Minimize or eliminate chemical connections.
5. Use bolted, screwed and nailed connections
6. Separate mechanical, electrical and plumbing (MEP) systems.
7. Design to the worker and labour of separation.
8. Simplicity of structure and form
9. Interchangeability
10. Safe deconstruction

A significant work programme in the Netherlands is also useful to consider in more detail. The Industrial, Flexible and Deconstructable (IFD) building programme [3] was set up by the Dutch government and ran until 2004. There were three calls for designs to be submitted that demonstrated IFD principles. The winning bids were then supported as demonstration projects for IFD. The demonstration projects would be interesting to look at in more detail to see how the design objectives were met in practice, and whether there were any particular barriers to implementation. However, the area that might be more useful to the current BRE project could be to look at the criteria used by the assessment panel to decide which projects should be funded. These are summarised as:

- Is an industrial production and construction method used?
- To what extent are the buildings (or parts of) flexible and deconstructable?
- Are new and innovative IFD building methods implemented?
- What is the scope for wider implementation to similar buildings?
- Is the targeted reduction in demolition and construction waste achieved?
- Does the proposal contribute to a more efficient construction process?

A discussion with some of the panel members may help to draw out the actual process used to measure the likely impact of the submitted proposals from a design perspective.

Going through these reports provides a sense of consistency in the key considerations that relate to designing for deconstruction. However, an assessment method would need to be able to weight the impact of inclusion (or not) of a consideration in terms of the resulting impact on future reuse, recycling and recovery.

6 WEIGHTING OF DESIGN CONSIDERATIONS FOR DFD

Ultimately, the current BRE project wants to produce a set of weighted design criteria that could be used to assess the level of deconstruction, reuse and recycling, and hence compare future performance at demolition stage. A useful starting point could be the work undertaken by Dr Paola Sassi, published in 2002 [6]. Here, the criteria for assessment are applied to each building element in relation to:

- Criteria for suitability for general dismantling, such as installation fixing methods, time and information required to dismantle elements.
- Criteria for suitability for reuse as a second hand item, such as durability, requirements for performance compliance and fixings needed for reinstallation.
- Criteria for suitability for reuse as new, includes an additional requirement to ensure aesthetic standards are met.
- Criteria for suitability for downcycling and recycling, such as reprocessing requirements.

Applying the individual criteria produces a score for ‘top’ rating and ‘bottom’ rating, i.e. best case and worst case scenario. These are then added up and normalised to give a score (between 0 and 1) to allow comparison of different design specifications at an element level. Looking at the output tables for specifications such as a range of floor finish specifications, there are possible synergies with BRE’s Green Guide to Specification [7] where an agreed assessment process could result in ratings for DfD for each specification, alongside the existing categories, such as ‘Climate Change’ and ‘Ecotoxicity’. Given that there are thousands of specifications, such an approach could be very time consuming and resource intensive unless there is a mechanism to automate data collection and subsequent interpretation into a single score or rating.

Another interesting perspective is to make a distinction between design decisions that facilitate reuse from those that facilitate recycling, as discussed in a paper by Philip Crowther [8]. Here, possible DfD principles are assessed as being 'very important' or 'less important' depending on whether the outcome is going to be reuse or recycling. For example, minimising the number of different types of connector is important, where labour is deployed to maximise the amount that can be subsequently reused, as this reduces the time taken to dismantle a building into its component parts. It is less important for recycling as it is likely that machinery will be used to demolish a building where recycling is the objective, rather than reuse.

7 OTHER INDUSTRIES

Having considered the existing knowledge base surrounding DfD in the building sector, a look further afield to other industry sectors may help in the development of an assessment methodology. The most advanced sector in this respect is the automotive sector, driven by the End-of-Life Vehicles Directive that came into force across the EU in 2000. This directive sets out binding targets that must be met by the automotive sector. The next target needs to be achieved by 2015 when a minimum of 95% by weight of scrapped vehicles must be reused, recycled or recovered (of which a minimum of 85% must be reused or recycled).

The important point is that manufacturers are responsible for ensuring these targets are met for their products. In the UK, these responsibilities are set out and regulated by BIS [9], and are summarised as:

- Meet vehicle design and information requirements, which includes a restriction on heavy metals, and any plastic or rubber materials and components, must be given a code so that they can be dismantled and recovered separately.
- Keep technical documents to show compliance with the design requirements for four years from the date the vehicles, materials and components are put on the market.
- Register with the Department for Business, Innovation & Skills (BIS) and declare responsibility for the vehicles produced.
- Implement an ELV take-back system, this has to be BIS-approved, free and reasonably accessible.
- Achieve recovery and recycling targets for the vehicles manufactured and with a declared responsibility for when they are scrapped. Details of the reuse, recovery and recycling rates achieved must be submitted to BIS on an annual basis.

In the absence of an End-of-Life Buildings Directive, it is unlikely that similar levels of resourcing or reporting will be possible in the building sector. However, some of these principles could be amended for use in the DfD of buildings, in terms of demonstrating best practice and providing evidence accordingly.

8 CONCLUSION

A review of existing work has shown that there is a readily available source of information that could be consolidated and built upon to form an assessment methodology for measuring design for deconstruction. The challenge will be to develop the assessment methodology in such a way as to be a robust and reasonably accurate assessment of the future deconstruction potential, easy to apply, able to use the data available at the point of detailed design, and able to be adapted easily in line with design and procurement changes.

9 REFERENCES

[1] Adams K., Hobbs G., Yapp C., 2012, Dealing with Difficult Demolition Wastes: A Guide, BRE (*estimated date of publication November 2012*)

[2] Pelsmakers S., 2012, The Environmental Design Pocketbook. RIBA Publishing

[3] Addis W., Schouten J., 2004, Principles of design for deconstruction to facilitate reuse and recycling CIRIA

[4] Morgan C., Stevenson F., 2005, Design for Deconstruction. SEDA Design Guides for Scotland: No 1, Scottish Ecological Development Association

[5] Guy B., Ciarimboli N., 2010, DfD Design for Disassembly in the built environment, City of Seattle, King County

[6] Sassi P., 2002, Study of current building methods and products that enable dismantling and their classification according to their ability to be reused, recycled or downcycled. Proceedings of SB2002, International Conference for Sustainable Building 2002, Oslo Sep 2002

[7] BRE Green Guide to Specification, www.bre.co.uk/greenguide

[8] Crowther P., Developing an inclusive model for design for deconstruction. 2001, Proceedings of CIB Task Group 39, CIB Publication 266, Wellington, pp. 1-26

[9] Department for Business, Innovation & Skills (BIS), www.bis.gov.uk, search for End of Life Vehicles

Standards Development Leading to Change in Design and Deconstruction Practices

Brian R. Kyle[1], Simon H.C. Foo[2], Dwayne Torrey[3]
[1] Xtn Sustainable Life-cycle Asset Management Consulting Ltd., Ottawa, Canada brian.kyle@xtn-slam.com
[2] Real Property, Public Works and Government Services Canada, Gatineau, Canada simon.foo@tpsgc-pwgsc.gc.ca
[3] Sustainability Standards, CSA Group, Mississauga, Canada dwayne.torrey@csagroup.org

Abstract
Enhanced building sustainability can be achieved by increasing the quantity of materials, components and systems that may be recycled or reused at the end-of-life. Building design should explicitly consider all disassembly opportunities throughout the life-cycle. Improved demolition and deconstruction practices increase efficiency of natural resource use, reduce greenhouse gases, and decrease quantities of materials going to landfill. This paper describes the standards development environment and processes in Canada, as well as the existing Canadian standards addressing design for disassembly and adaptability (DfD/A) and effective deconstruction and disassembly. The initiation of new ISO standards development activities on DfD/A is also discussed.

Keywords:
building standards, deconstruction, design for disassembly and adaptability, sustainability

1 INTRODUCTION

In the quarter century since the publishing of the Bruntland Commission Report on Environmental Development [1], the core issues and requirements to meet the objectives of sustainable development (economic development; social equity and justice; and environmental protection) remain relatively unchanged.

Historically, the majority of the greening efforts associated with buildings and construction has centred on improving energy efficiency and reduced consumption. The promise that green buildings will have higher energy performance pleases building owners and operators on two distinct levels; an altruistic motivation to be environmentally friendly and the direct economic benefit of using less energy. Relatively little attention has been paid to the potential environmental and economic benefits of sound life-cycle management of construction materials.

Construction, renovation and demolition waste accounts for roughly a quarter of the solid waste disposal in Canada. In some regions of Canada there has been an increase in public awareness and concern over the shortage of available landfill disposal sites, subsequent excessive haulage distances for municipal waste, as well as greater consciousness of end-of-life resource utilisation issues. These concerns have resulted in several provincial and municipal jurisdictions implementing various controls on the responsibilities for end-of life material handling, on the makeup of the material sent to their landfills as well as controlling the tonnage being sent to landfill, in or out of their jurisdictions. In addition, there have been high level intergovernmental discussions to potentially broaden the application of Extended Producer Responsibility (EPR) to cover some conventional building products, most notably asphalt shingles [2].

Significant improvements in overall environmental stewardship and building sustainability could be made by increasing the quantity of materials, components, products and systems that may be recycled or reused at the end of a building's life-cycle. Such changes would lead to direct economic benefit to the recycling and reuse communities, produce longer lasting and adaptable facilities to the advantage of property developers, and ease the burden on landfill sites as well as reduce energy consumption.

To help make this a reality, the building design stage should explicitly consider disassembly requirements that may occur in normal life-cycle operations and maintenance activities as well as the more evident needs at the end-of-life. Similarly, enhanced and consistent demolition and deconstruction practices would improve the capacity of the building industry to contribute to the sustainable use of natural resources, reduce greenhouse gases, and decrease quantities of products and materials entering waste disposal sites.

The International Council for Research and Innovation in Building Construction (CIB) made an early identification of the potential contribution of deconstruction to sustainability objectives; significant in this regard was the initial work of CIB Task Group (TG) 16: Sustainable Construction. The collective works of CIB TG 39: Deconstruction, and subsequently CIB Commission W115: Construction Materials Stewardship [3,4,5,6,7,8,9,10], have provided immeasurable and invaluable guidance relative to deconstruction and material harvesting practices as well as development of various models for the Design for Deconstruction and the later distinguishing term Design for Disassembly (DfD). With time, the significance of adaptability to the life-cycle design and sustainable performance of buildings has become very evident; many of the efforts of CIB W115 now explicitly considering adaptability [9].

In 2004, in support of sustainable development initiatives of governments and the building industry, the CSA Group (CSA) established a Technical Committee (TC) on Sustainable Construction Practices (formerly the TC on Sustainable Buildings); tasked to develop national standards to advance the design, construction and maintenance of buildings in a sustainable manner.

The remainder of this paper describes the standards development environment in Canada, the standards development process at CSA and goes on to describe the development and content of standards on DfD/A of buildings and a new standard identifying the procedures for effective deconstruction and disassembly. The recent acceptance and pending initiation of new standards development activities, under the purview of the International Organisation for Standardisation (ISO) TC 59 (Buildings and civil engineering works) based upon the CSA DfD/A document, is also briefly discussed.

2 STANDARDS DEVELOPMENT IN CANADA

The Standards Council of Canada (SCC) coordinates Canada's National Standards System and ensures Canada's input on standards issues in international standards organizations. The SCC accredits Canadian standards development organizations (SDOs) and also approves Canadian standards as National Standards of Canada based on a specific set of requirements. CSA is one of four accredited SDOs in Canada. Many of the standards developed by CSA are explicitly referenced in the building codes within Canada and as such, fulfilment of their stipulations becomes legally binding. Other CSA documents carry similar legal status once cited within contractual documents.

2.1 CSA - Standards Development Process

CSA, established in 1919, is the oldest and largest accredited SDO in Canada. CSA is a national, independent, not-for-profit membership association, serving business, all three levels of government and consumers in Canada and globally, with over 3000 published standards and codes. CSA's employees, with the involvement of its 8500 committee members develops product, system, and competency standards, codes, and other information products that promote public health and safety, improve the quality of life, preserve the environment, and facilitate trade. CSA's solutions address 54 different program areas such as environment, construction, quality, business management, energy, health care, public safety, and communications. CSA's overriding purpose is to make standards work for people and business.

CSA standards are developed using an accredited consensus-based process, ensuring respect for and input from diverse stakeholder interests. Volunteer experts develop the technical content of standards, represent various interest groups, ensuring relevant and balanced stakeholder participation. CSA committees are created using a "balanced matrix" approach, which means that each committee is formed in a way so as to capitalize on the combined strength and expertise of volunteer committee members. Volunteers are dedicated people from many walks of life such as business and industry, science and academia, labour, government and consumer groups. The time and expertise of volunteer committee members results in valuable in-kind contributions to the development of standards. The committee considers the views of all participants and develops the details of the standard by a consensus process. Substantial agreement among committee members, rather than a simple majority of votes, is necessary.

In accordance with the stipulations of the National Standards System and the standards development process, CSA formally reviews all standards for reaffirmation, withdrawal, or development of a new edition, every five years.

2.2 CSA TC on Sustainable Construction Practices

Early planning relative to standardization efforts on Sustainable construction practices began in 2002 and 2003 with three exploratory meetings amongst the main industry stakeholders. The meetings, organized by two federal government departments, Natural Resources Canada and Public Works and Government Services Canada, as well as CSA, brought together participants from government, representatives from the construction and design industries, CSA, and academia.

The main focus of these meetings was to discuss environment and sustainability issues in the built environment in general and the needs of the building industry in terms of the design, construction and maintenance of buildings respecting sustainability requirements in particular.

In 2004, CSA established a new TC on Sustainable Buildings (later renamed TC on Sustainable Construction Practices) whose main responsibility was to develop technical standards for the design, construction and maintenance of buildings respecting sustainability. Members of the new TC included most of the participants from the initial exploratory meetings and new members in order to provide broader representation of the relevant industry sectors and to meet the CSA directives on the balanced of member interests. The membership and expertise of this committee has changed and continued to evolve over the past eight year, as new capabilities were required, participants or affiliations changed and new work items emerged. The TC is free to benefit from the contributions and expert opinion of nonCanadian members so long as the blend of interests and capacities of the voting membership complies with the CSA directive governing balanced participation.

3 CSA GUIDELINE FOR DFD/A IN BUILDINGS

The preliminary meetings, mentioned above, had identified the 'design for disassembly and adaptability' as an area of interest in which there had not been any significant standards development activities elsewhere and as such a potential source of impact for the TC. With the intention of the long-term evolution and development of a full blown standard on this subject, the TC decided to produce a document to provide guidance on the conceptual framework, concepts and principles for the design of buildings following disassembly and adaptability principles. Feedback from the industry through field applications of the Guideline as well as any emerging research findings would be used to promote the guideline to a standard in the future.

The Guideline was developed using the consensus-based approach described above, in Section 2.1. The first edition of 'Guideline for Design for Disassembly and Adaptability in Buildings, CSA-Z782-06' [11] was published under the auspices of CSA in November 2006.

The CSA Z782 details a framework for reducing building construction waste via consideration at the design phase, by applying DfD/A principles. The objective of this Guideline is to provide an overview of DfD/A principles and a method of defining the scope of integrating these principles into the design process to reduce the overall environmental burden associated with material assemblies. Its contents include DfD/A conceptual framework, DfD/A concept, specific principles and annexes. The Guideline also reviews quantifiable metrics for each DfD/A principle that, subject to further development, can be assembled into a matrix or checklist to guide users in the direction of disassembly criteria design.

The Guideline can be used by architects, engineers, planners, building owners and environmental professionals to increase their understanding of their options, and by other parties who are responsible for designing, constructing and demolishing buildings. The Guideline is not to be used as a design tool; rather, it can be used to aid the comparison of environmental performance of various design options within the context of DfD/A principles. The CSA Z782 outlines and discusses the following 14 DfD/A principles:

- versatility;
- convertibility;
- expandability;
- accessibility;
- documentation of disassembly information;
- durability;
- exposed and reversible connections;
- independence;
- inherent finishes;
- recyclability;
- refurbishability;
- remanufacturability;
- reusability; and
- simplicity.

For each principle, a general discussion is given along with examples of potential strategies and measurable metrics. Using 'versatility' as an example, the general discussion would start with 'versatile buildings and spaces lend themselves to alternative uses with minor system changes'. Examples of potential strategies include building areas for multiple purposes part of the design and construction, e.g. a gymnasium can double as a community theatre. Measurable metrics can include the percentage of floor space or building footprint that has multiple uses on a daily, weekly or monthly basis, without requiring changes to the main features of the space.

Using 'durability' as a second example, the general discussion defines durability as 'the ability to exist for a long time without negatively impacting building performance or service life' and that 'durability provides reduced environmental impact by minimizing the maintenance or replacement of a product'. Examples of potential strategies include the use of materials with a high durability rating that require less frequent maintenance, repair or replacement. Measurable metrics can include the cost of maintenance as a percentage of purchase price and the lifespan of a given product compared to alternative products that serve the same function at the same performance.

The Guideline also includes an Annex on the feasibility assessment of design for disassembly options. A table was given to illustrate examples of specific elements or components/assembles being assessed for each DfD/A principle. Examples are related to mechanical systems, such as ducting, diffusers, pipes, flexible tubing, and connectors. Examples on flex duct options are shown in Table 1.

The same process can be used for other elements at the structural, building envelope, services or fit-up level. The tabular format can be used to assess early outline specifications to ensure DfD/A issues are being addressed and to identify opportunities for improvement.

4 CSA STANDARD FOR DECONSTRUCTION OF BUILDINGS AND THEIR RELATED PARTS

The composition of the TC on Sustainable Construction Practices was slightly reworked and broadened to engage deconstruction experts and the consensus-based approach, as described in Section 2.1, was applied for the development of the standard. The first edition of 'Deconstruction of buildings and their related parts, CSA-Z783-12' [12] was published in March 2012.

The Standard specifies minimum requirements for processes and procedures related to the deconstruction of buildings and is intended to be used by contractors, consultants, designers, building owners, regulators, and material supply and value chain organizations involved in deconstruction of a building that is at the end of its service life or undergoing renovations or alterations.

The Z783 applies to existing buildings where deconstruction is to be considered as a means to reconfigure, remove, or partially remove an existing building. The document provides the minimum criteria for the planning and management of a deconstruction project, including:

- the establishment of scope of a deconstruction effort; and
- the planning and procurement;
  - contract development and identification of required skill sets and responsibilities;
  - deconstruction plan – material recovery targets, material separation plans, process descriptions, and schedule description and coordination.

The Standard acknowledges that it is possible that materials or components removed from any given building will need to be assessed before reuse in another application and further states that that process is outside the scope of this Standard. The Z783 recognises that various jurisdictions may have laws or regulations with regard to special precautions and handling of goods, substances, and materials (including waste), and provides examples of materials or components that an assessment might deem unacceptable for reuse, potentially requiring special handling for recycling include those not meeting government efficiency, safety, or performance requirements.

As well, this Standard recognises that health and safety requirements are addressed by other existing CSA Standards and does identify the need for health and safety provisions in specific clauses

Because numerous options are available for deconstructing, removing, and separating materials and components, the Standard has not set any requirements on methods to be used. For example, separating and palletizing materials can be a logical decision for one project, whereas shipment of commingled materials can be a better decision for another project. However, the Standard contains an informative Annex that identifies procedures for typical materials removal, separation, and protection scenarios.

As well the Standard provides basic information on the tools to be used for deconstruction efforts, accepts that care shall be taken to avoid contamination of materials, components, products, and systems, and stipulates that recovered materials shall be tracked and records maintained during deconstruction, with review of records by the building owner on a regular basis. The Standard provides an informative sample deconstruction planning form. Table 2 depicts the summary sheet for that form. Further, the Standard requires that the deconstruction contractor provide a final report confirming that the deconstruction work has been performed in accordance with the deconstruction plan.

Design for disassembly summary	Versatility	Convertibility	Expandability	Durability	Accessibility	Independence	Simplicity	Reusability/recyclability	Refurbishability/ remanufacturability	Exposed/reversible connections	Inherent finishes	Documentation of disassembly information
Flex duct												
Flexible ducts can be reused and rerouted and are simple and easy to install	X		X				X			X		
Pre-insulated option is available							X					
Specify quick clamp connections										X		

Table 1: Sample assessment of design for disassembly and accessibility options [11]

Division*	Base material or component	Recovery targets		Actual recovery		% Reuse†	% Recycle	% Energy	% Waste
		Quantity	Units (m3 , m, kg)	Quantity	Units (m3 , m, kg)				
4									
5									
6									
7									
8									
9									
10									
11									
24									
33									

*Based on the National Master Specifications MasterFormat™ numbering system (see Clause B.2).

†See Clause 4.3.4 regarding suitability of materials for reuse.

Reuse target (%)	
Reuse actual (%)	
Recycle target (%)	
Recycle actual (%)	
Energy recovery target (%)	
Energy recovery actual (%)	
Waste target (%)	
Waste actual (%)	

Table 2: Deconstruction planning form – Summary sheet [12].

5 NEXT STEPS FOR THE CSA STANDARDS

The TC on Sustainable Construction Practices plans further development and elaboration of the CSA-Z782, with the objective of elevating the document from a guideline to a national standard. The TC Communication strategy has been developed in order to promote the use and the acceptance of the Z782 by various facets of the industry. This strategy will be further modified to raise awareness of the development of the Z783.

The TC has an on-going plan to collect data on the application of DfD/A principles and corresponding environmental benefits from past, current and future field applications. New research on the development of the DfD/A principles into framework, indicators, a method for understanding potential performance and a procedure for evaluating/comparing relative environment performance of DfD/A design options for office fit-ups is being considered.

In September of 2011, a Canadian representative to the ISO Technical Advisory Group (TAG) 8 Buildings, proposed a new work item for the development of an ISO standard on DfD/A and recommended using the CSA Z782 as a seed document. ISO has embraced the idea of the new work item, accepted the offer to employ CSA Z782 and has placed the standards development project under the purview of ISO TC59 - Buildings and civil engineering works. The work item is tentatively assigned to Subcommittee (SC) 17-Sustainability in buildings and civil engineering works, dependent upon that SC's acceptance of the task at the General Meeting of TC59, to be held in Tokyo in October 2012.

ISO TC59's acceptance of the CSA Z782-6 as seed document directly implies a desire by ISO TC59 for Canadian involvement in the future development of ISO standards on DfD/A. Several members of the CSA TC on Sustainability of Building Construction are also active members of the Canadian Mirror Committee to ISO TC59/SC17 and it is expected that at least one of those members will participate in the new work item, and anticipated that one of those members will be requested to head the unit assigned the task.

6 SUMMARY

As public concern on environmental and sustainability issues has risen, so too has comprehension of the impact and interaction between the built and natural environments. There is a pressing requirement to promote sustainable development and, as a result of the increased awareness and concern, a great potential for successful public acceptance of the required corrective and adaptive measures. This will require a modification to the conventional perspectives of standards and codes.

Traditionally, building codes and standards for design and construction have dealt primarily with the fulfilment of health and safety needs. Environmental and sustainability objectives are usually not addressed in building codes. Even the relatively inarguable necessity for improved building energy performance is inextricably linked to occupant-related health aspects such as indoor air quality and thermal comfort. Given the continuing increase in public concern over our environment and natural resource issues, and the maturing of the sustainable building industry, it is conceivable that building codes will one day address and include environmental and sustainability objectives.

It is essential that guidelines and standards, providing direction on the design, construction and maintenance of sustainable buildings be developed in support of the sustainable building industry's immediate needs and the potential requirements of future building code development to include environmental and sustainability objectives. Deconstruction, and DfD/A Guidelines are two tools that will lead to improved sustainability of built assets and standardization of those procedures will further enhance the benefits.

The standards development environment employed by CSA provides a forum for common ground, consensus building and continual improvement essential to a sustainable Canadian built environment. Since the publication of the CSA Z782 Guideline for Design for Disassembly and Adaptability in Buildings in 2006, and with the recent release of the CSA Z783 Standard on Deconstruction of buildings and their related parts, the CSA, together with the industry has been actively working towards information dissemination and further public recognition and acceptance of the direct impact that modified building design and deconstruction practices can have upon sustainability.

The next standardization and distribution venue is to be ISO. The development of DfD/A standards on an international level will provide the opportunity for the establishment of documents describing flexible, yet widely applicable, procedures toward a sustainable built environment. Essential to this is input from international experts in design, construction and deconstruction, with experience in various regulatory frameworks and jurisdictions. The base intent of ISO, and international standardisation, is to have/retain/maintain an internationally level playing field for any given domain, and the key to taking that notion to fruition is the diversity and completeness of expert opinion. Experts wishing to participate in the ISO TC59 DFD/A initiative are strongly encourage to contact their national standards member body of ISO.

7 ACKNOWLEDGEMENTS

The authors of this paper gratefully acknowledge the contributions of the members of the CSA TC on Sustainable Construction Practices toward the development of CSA Z782-06 and the CSA Z783-12. Permission by CSA Group to include excerpts of Z782-06 and the Z783-12 in this paper is greatly appreciated.

8 REFERENCES

[1] United Nations', 1988, Our Common Future. World Commission on Environment and Development (UNWCED), Oxford University Press, Toronto, Canada.

[2] Kyle, B.R., 2008, 'Pending Changes to Roofing Waste Diversion Practices', Roofing Canada - Spring/Summer, Canadian Roofing Contractors Association, Ottawa, Canada.

[3] CIB 2000, TG 39 Deconstruction. Overview of Deconstruction in Selected Countries. CIB Publication 252, International Council for Research and Innovation in Building and Construction.

[4] CIB 2001, TG 39 Deconstruction. Deconstruction and Materials Reuse: Technology, Economic and Policy. CIB Publication 266, International Council for Research and Innovation in Building and Construction.

[5] CIB 2002, TG 39 Deconstruction. Design for Deconstruction and Materials Reuse. CIB Publication 272, International Council for Research and Innovation in Building and Construction.

[6] CIB 2003, TG 39 Deconstruction. Deconstruction and Materials Reuse – *Proceedings of the 11th*

Rinker International Conference, CIB Publication 287. International Council for Research and Innovation in Building and Construction.
[7] CIB 2005, TG 39 Deconstruction. Deconstruction and Materials Reuse – An International Overview. CIB Publication 300, International Council for Research and Innovation in Building and Construction.
[8] CIB 2008, W115 Construction Materials Stewardship. The status quo in selected countries. CIB Publication 318, International Council for Research and Innovation in Building and Construction.
[9] CIB 2009, W115 Construction Materials Stewardship. *Conference Proceedings - Lifecycle Design of Buildings, Systems and Materials*, CIB Publication 323, International Council for Research and Innovation in Building and Construction.
[10] CIB 2011, W115 Construction Materials Stewardship. Construction Waste Reduction around the World. CIB Publication 364, International Council for Research and Innovation in Building and Construction.
[11] Canadian Standards Association, 2006, 'Guideline for Design for Disassembly and Adaptability in Buildings, CSA-Z782-06', CSA Group, Mississauga, Canada.
[12] Canadian Standards Association, 2012, 'Deconstruction of buildings and their related parts, CSA-Z783-12', CSA Group, Mississauga, Canada.

The Tectonic Potential of Design for Deconstruction (DfD)

Søren Nielsen, Olga Popovic Larsen
The Royal Danish Academy of Fine Arts, Institute of Technology, Copenhagen Denmark

Abstract

Along with the implementation of high standards for energy saving in new buildings further resource conserving action must focus on strategies for prolonging the lifetime of buildings, their parts, components and materials. Spatial and technical strategies must be deployed to increase buildings' capacity for transformation according to change. Design for Deconstruction (DfD) is a technical strategy enabling changes in building configuration without generating waste. DfD has primarily been described as a technical matter, e.g. reversible connections and layering. However, the architectural potential is considerable, and actualises the concept of 'tectonics'; architectural expression by means of construction. By systematically investigating the relationship between technical guidelines of DfD and tectonic articulation, resource conserving necessity may turn into an attractive inspirational source for architects. Through a number of case studies, relations are mapped and tectonic potentials are registered. Hereby, the architectural potential can be detected, documented and categorised as tectonic motifs.

Keywords:
Resource conservation, Design for Deconstruction (DfD), tectonics, assembly diagram, motif

1.0 RESEARCH AIM AND CONTEXT

On the background of a future agenda of conserving resources, architectural design practice is facing a shift in its technical paradigm: From designing for permanence to designing for constructive reversibility. This change will stimulate the technical core competencies of the architectural profession, actualising the concept of *tectonics*; artistic expression by means of construction.

The study described in the following attempts to point out ways to describe the connection between Design for Deconstruction (DfD) and architectural design strategies. The motif generating potential of DfD is demonstrated through technical and tectonic analysis of case examples.

1.1 The resource agenda

Today in most European countries, the lowest hanging fruits of energy saving have been reaped by saving energy for building operation. To reach further goals, lifetime processes and embodied energy must be addressed as a design parameter. Though 50% of demolishing waste is recycled, little is prepared for reuse and large amounts of resources are lost.

The reuse ratio could potentially be raised drastically and huge amounts of resources could be saved if buildings and components were designed for deconstruction. Technical guidelines must be taken into operation by building designers but the potential is far from only technical as cultural value to buildings might be added simultaneously.

While resources can be assessed by life-cycle assessment (LCA), the cultural assets of building identity cannot be calculated quantitatively, and yet identity has the capacity to become the most critical factor of longevity, as buildings that lose their cultural status are more likely to be demolished.

1.2 Solution strategies

DfD, as technical solution and as architectural strategy, must be seen in relation to the three main strategies for resource preserving:

Longevity of buildings: Minimizing resource consumption for building interventions e.g. replacements, conversions, additions and maintenance. This can be obtained by adaptability, e.g. versatility, convertibility and scalability [1], by means of robust **spatial** composition: large free spans, generous ceiling height and surplus structural capacity.

Longevity of components: Avoiding waste generating and downcycling by **technical** strategies, e.g. refitability, movability and adjustability by designing for deconstruction (DfD). DfD covers a wide range of guidelines and recommendations. Based on previous research [2] a short set of technical design rules of particular relevance to architectural design, comprises:

1. Reversible fixations, enabling deconstruction without damage of materials. This implies in general mechanical assembly rather than chemical (cast, glued).
2. Hierarchical assembly according to component lifetime, enabling interventions with a minimum of interference in components with longer lifetime.
3. Accessibility of fixations, enabling deconstruction without damaging components.
4. Parallel assembly, enabling local exchange of single components.
5. Handleable size and weight of components, enabling changes and deconstruction without crane-lifts.

6. High generality (modularity, homogeneousness and uniformity) increases the reusability of components.
7. Minimum of mechanical degradation, e.g. cutting, carving and penetration, minimises waste and increases the reusability of components.
8. Orthogonal geometries (rather than skewed or curved) minimises waste and increases the reusability of components.
9. Minimal number of component types eases as well the deconstruction as the salvaging process.

Cultural value: longevity can be pursued through cultural value by achievement of a protecting 'lovability' [[3]]. As only a minority of buildings will achieve protection or even conservation, DfD constitutes a 'safety net strategy' by ensuring the possible salvaging of building materials for reuse at end of life. By cultivating DfD to increase cultural value, e.g. by exquisite detailing, a double, strategic 'safety net' can be held under the building resources.

2.0 TECTONICS

How can DfD be deployed in order to increase buildings' cultural value? Constructive reversibility, as the primary command of DfD, highlights the significance of bringing construction technology into the very centre of architectural design. In this respect, the notion of tectonics might be a key to evoke a new resource saving building culture.

Tectonics can be defined as *'a certain expressivity arising from the statical resistance of constructional form'* [[4]] and correspondingly: *'the atectonic: visually neglecting or obscuring the expressive interaction of load and support'.* The following cases represents an approach to link tectonics with DfD in a systematic way by demonstrating how DfD is simultaneously an engineering discipline and an architectural strategy: Architectural motifs are generated from hierarchical assembly according to lifetime layers and from features of mechanical assembly enabling such as bolts, brackets, screws or springs.

3.0 METHODOLOGY

This study is based on investigation and analysis of four case studies chosen among housing schemes, the functional category constituting 75% of the total built area: Two high-profiled demonstration projects, and two ordinary low-cost residences displaying deconstruction as an inherent part of industrialised construction systems. The cases below are all designed to meet contemporary regulatory standards for building insulation.

3.1 Analytic tools

Cases are analysed in parallel: Technically, by assembly diagrams, and narratively, by denotation of the tectonic principles behind the architectural motifs.

Assembly diagrams

The assembly-diagram translates actual technical solutions into visualisations of component placement in a layered structure. By analysing the assembly structure, the actual capacity for deconstruction is documented by ensuring that disassembly can take place without interference in more permanent neighbouring layers. From the assembly diagram it is possible to map the logistic and technical functionalities that conditions the tectonic motifs.

Detail drawings

Narratives attached to the technical solution unfold in the scale of the detail [[5]], making the 1:5 drawing the primary study object, fig. 1. On the technical level, constructions are described according to the functionality of the component, and the delineation between DfD and non-DfD parts are marked and similarly are marked a boundary between off-site and on-site construction.

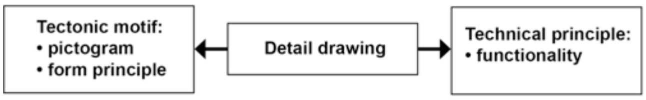


Figure 1: Principle diagram; parallel study of technical principles and tectonic motifs.

On the tectonic level, constructions are described as actions of designing, such as 'hanging', 'clamping', 'penetrating', etc., and denoted by pictograms. These actions represent architectural motifs attached to the assembly technique. By identifying basic form principles from actual designs, an 'alphabet' of tectonic categories can be developed.

3.2 Case presentation

Case 1: Bolig+ by Vandkunsten 2009 is a scheme for an open building system with energy consumption below zero obtained by means of passivehaus technology and integrated renewable energy sources. Spatial versatility and reversible assembly technique are employed as long-term resource-saving strategy.

In order to separate the more volatile skin layer from the permanent structural layer (prefab concrete elements), non thermal-conducting intermediary consoles of fibreglass are attached to the slab edges, resulting in a gargoyle-like motif, fig. 2, onto which additional applications can be mounted such as balcony element, sunscreens or windshields.

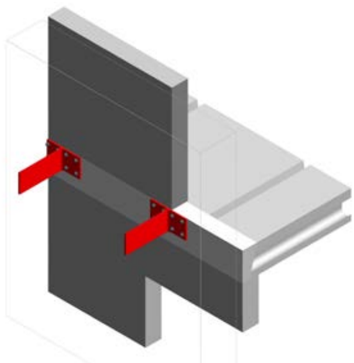


Figure 2: Vandkunsten Bolig+: consoles for connecting climate shield and applications to structural layer.

The separate structure and skin layers are visibly displayed in the interior, fig. 4, as a double framing motif enforced by different materials: concrete and wood. In this, the motif appears as a combination of two layers. The console element exemplifies how mechanical connections can be designed as autonomous components rendering an architectural motif, figs. 2-6.

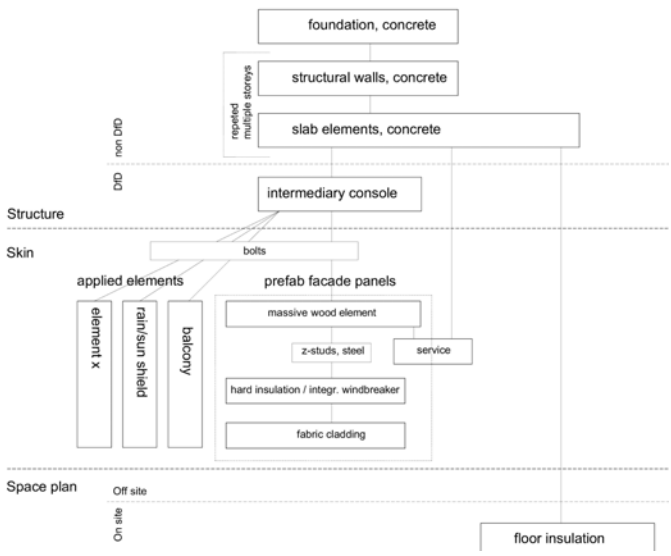


Figure: 3: Vandkunsten Bolig+, assembly diagram.

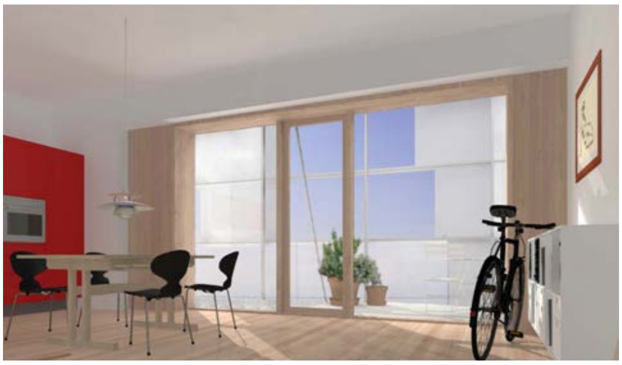


Figure 4: Vandkunsten Bolig+, proposal for zero-energy residences 2009, interior with exposed layering of facade elements.

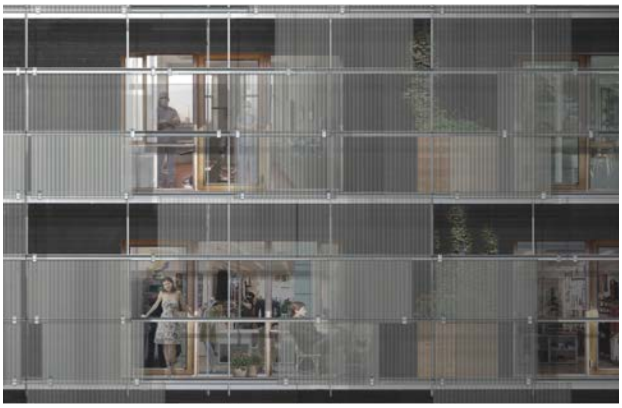


Figure 5: Vandkunsten Bolig+, proposal for zero-energy residences 2009, section of façade.

Case 2:

Kvistgård by Vandkunsten is a scheme for low-dense, low-cost residences built with prefabricated panel-elements. The buildings are assembled in a way that enables reversible action. By turning the cladding board from vertical (pre-mounted) to horizontal (mounted onsite) the assembly connections between panels are manipulated into a characteristic motif of two layers of boxes sliding on top of each other, figs. 7-8. As the stud-frame structure is atectonically hidden by cladding on both sides, all visible motifs appear in the skin layer, fig 9.

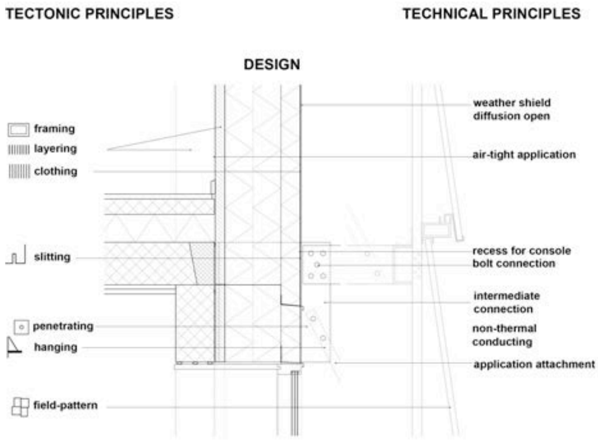


Figure 6: Vandkunsten Bolig+, façade detail.

Figure 7: Vandkunsten 2007 Kvistgård. Photo by Adam Mørk.

Figure 8: Vandkunsten Kvistgård, low-dense terraced housing 2007.

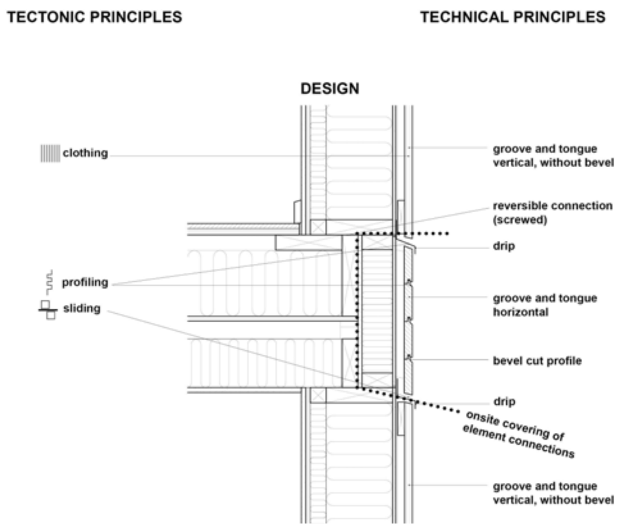


Figure 9: Vandkunsten 2007 Kvistgård, façade detail.

Figure 10: Vandkunsten 2007, Kvistgård, assembly diagram. Structural members and the complete skin layer are integrated in prefab panel elements except for the on-site façade cladding covering the connections.

Case 3:

Almen+ by Vandkunsten is a scheme for low-cost terraced housing based on prefab volumetric elements with stud-frame structure and cladding of hard, fibre-reinforced gypsum.

While connections between volumes are hidden, the secondary construction for the façade cladding comes to define the dominant exterior motif, figs. 11-14: Pitched boards, reflecting the on-site mounting process where boards are placed in position from a lift. By using stock-measured board modules and frictional fixation screws, instead of drilled penetrations the cladding construction is designed for disassembly. Rhythmically placed steel hooks generate a characteristic motif.

Figure 11: Vandkunsten, Almen+, section of façade module.

Figure 12: Vandkunsten 2009, Almen+, block typology.

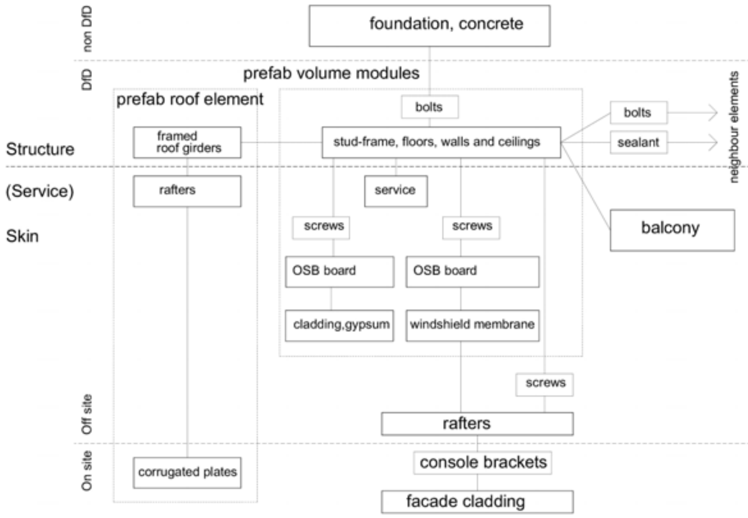


Figure 13: Vandkunsten 2009, Almen+, assembly diagram.

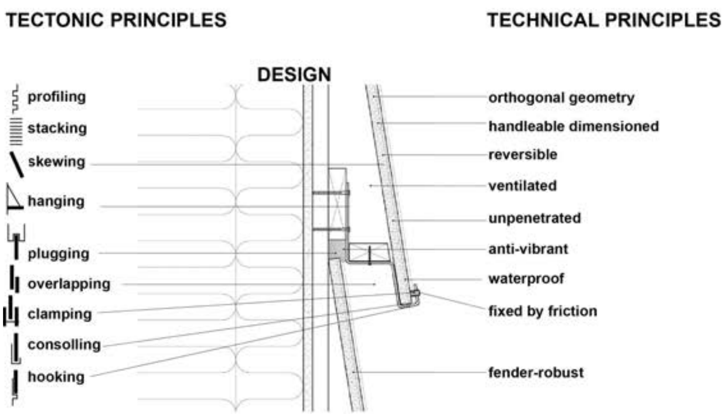


Figure 14: Vandkunsten 2009, Almen+, façade detail.

Case 4:

The Loblolly house is a single-family holiday residence designed for a maximum degree of prefabrication. The structure is a patented scaffolding system of extruded aluminium profiles assembled with steel connections forming a 3D framework in which wooden stud-frame volumes are inserted.

In Loblolly House a series of motives are displayed in parallel, each one of them connected with the respective constructive layer: The structure designed by the

Figure 15: KieranTimberlake, Loblolly House, assembly diagram. The construction performs a full DfD-design as even the foundation can be dismantled.

Figure 16: KieranTimberlake, Loblolly House 2008, exterior. Photo by Ulrik Stylsvig.

manufacturer (Bosch) becomes an adopted motif, whereas the fragmented sections of pre-fabricated wooden façade cladding stand out as an original, individually designed motif. In terms of layering, the wooden boards constitute a mere surface function of the skin layer, locating the buildings' exterior identity in the most volatile part of the assembly hierarchy.

4.0 INTERPRETING DFD-RELATED MOTIFS

From the cases analysed above, that exemplifies how reversible assembly and tectonic motifs correlate, a number of phenomena can be found.

In all cases it is the structure and skin layers that are subject to articulation efforts, whereas service, space plan layers appear atectonic due to hidden connections. In other buildings motifs might be found emerged from those layers.

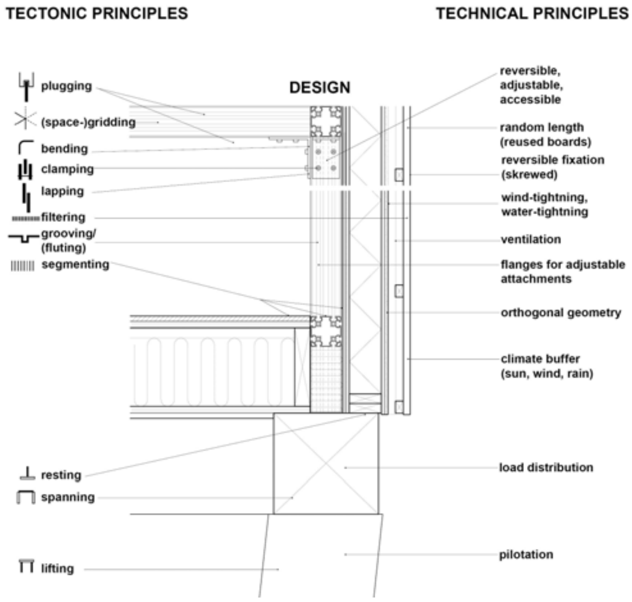


Figure 17: KieranTimberlake, Loblolly House, facade detail.

The motifs found in the four cases are related to the DfD-principles as displayed in the matrix below, fig. 18. From the matrix a number of characteristic features can be found:

1. *Unexploited potential:* The matrix makes it visible to what degree the DfD guidelines has not been a vehicle for architectural expression.

2. *All DfD guidelines are potentially motif-generating*: Motifs are found with all categories of guidelines.

3. *Mechanical, connections are most rich in motifs:* Mechanical, accessible connections, typically found with steel and aluminium joints, produce significant motifs often with ornamental and decorative qualities.

4. *Super-motifs:* Some motifs are found to relate simultaneously to a multiplicity of guidelines, e.g. the sliding motif in Kvistgård and the frame-structure of Loblolly.

5. *DfD-related motifs are found along with non-DfD-related motifs:* Even when DfD principles are followed consequently motifs emerge with no reference to DfD. At the level of volumetric composition motifs are found which are not specific to DfD though produced by DfD assembly methods.

6. *Scale:* Tectonic articulation, by means of reversible assembly details, materialises at different levels of scale. Assembly details can generate motifs in macro-scale. In the Kvistgård case the displacement of volumes is narrated as an event of sliding on the 'rail' of the horizontal cladding. Loblolly's scaffolding grid attains a three dimension plug-in motif at the volumetric scale. Motifs such as stacking, sliding, segmenting or cantilevering are found to be scale independent.

7. *Lifetime layers* Constructive layering in itself can produce significant motifs at multiple scale levels as found in the frame-and-filling motif of Loblolly and the double frame motif of Bolig+.

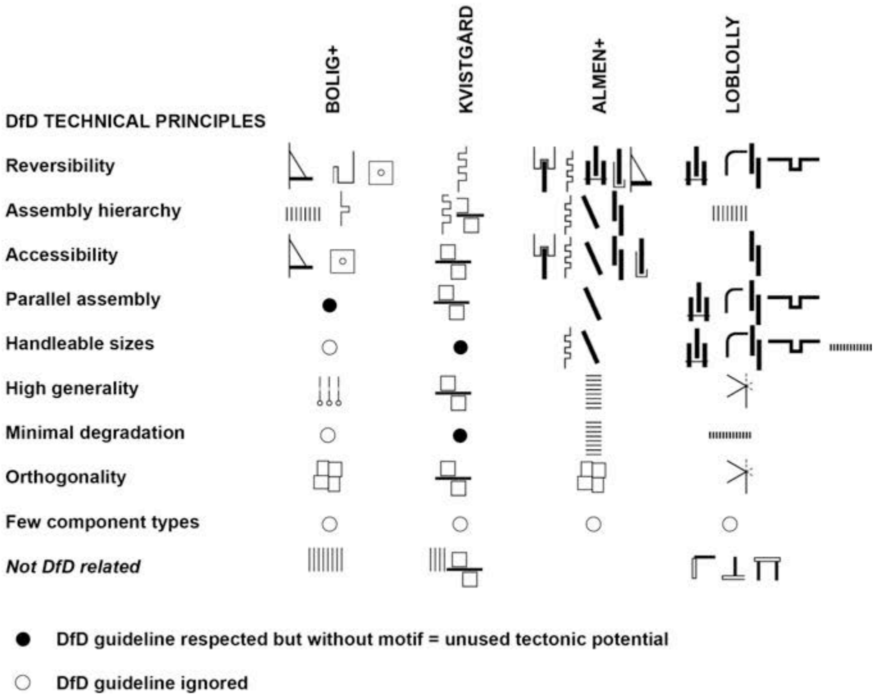


Figure 18: Matrix showing tectonic motifs' relation to DfD guidelines.

In insulated constructions the most identity constituting elements can be found as highly peripheral parts of the structural hierarchy, which confirms that the narratives of modern architecture unfold at the surface level as a consequence of technical independency between façade and structure [6]. Within a DfD regiment buildings become 'paper-dolls' allowing the exterior identity to be easily changed by tacking façade element to intermediate structures. This strengthens the buildings' robustness but challenges authorship by assigning influence to users and second-generation designers.

5.0 CONCLUSION

The DfD building technique is capable of being integrated in architectural design as a resource of motifs that can be used for adding individual identity to buildings. The relationship between technical guidelines and motifs can be decoded as attempted above and revealing a multiplicity of architectural expressions is revealed.

5.1 Architectural potential

Architects may on the one hand dismiss tectonic opportunities in DfD in the structural layer when members are integrated due to insulation thickness, but numerous motifs can be created within and between the more volatile layers. This implies an increased focus on buildings' details, including assembly logistics that are, however, somehow peripheral disciplines in much architectural design practice. Bringing the methods of DfD into the core repertoire of design practice might change this picture and result in long-term resource savings. Though the commitment to technical reversibility imposes some new restrictive conditions to the design framework, new means for expression occur from finding constructive solutions to the challenge.

5.2 Perspectives

By incorporating DfD in the repertoire of architectural profession as a means of expression, the development towards a resource-gentle building practice can be pushed forward. While there is a developed body of knowledge on the technical aspects of DfD, the architectural potentials of DfD are still relatively unexplored, partly due to the lack of empiricism. Further research in e.g. the potential of specific materials, technical functionality or architectural themes can expand the field.

The architecture of DfD might eventually have a cultural perspective: DfD may change the ways buildings are conceived into a more dynamic direction, since DfD technically allows an increased influence from users and other_stakeholders.

[1] Schneider, T. and Till, J. 2007: Flexible Housing, Elsevier Oxford

[2] Addis, W. & Schouten, J. 2004. Design for deconstruction. Principles of design to facilitate reuse and recycling. London: CIRIA, Durmisevic, E.2006: Transformable Building Structures, Doctoral thesis, Technical University Delft, Sassi, P. 2008: Closed Loop Material Cycle, Doctoral thesis, Cardiff University, Nordby, A.S. 2009. Salvageability of building materials. Doctoral thesis NTNU

[3] Eberle, J. in: Nerdinger, W. (ed) 2007: Baumschlager+Eberle, Recent Projects 2002-2007 Architecture, People and Resources, Wien, Springer

[4] Eduard Sekler, "Structure, Construction & Tectonics" in Structure in Art and in Science, New York, 1965, pp. 89-95.

[5] Frascari, M. 1984: The tell the tale detail – in Via7, University of Pensylvannia p. 23-37

[6] Leatherbarrow, D. and Mostafavi, M. 2002: Surface Architecture, The MIT Press, Cambridge Massachusetts

Cradle to Cradle strategies for the management of waste in the building sector: strengths and weaknesses of the Italian reality

P. Altamura[1]

[1]DATA - Department of Industrial Design, Architecture Technology, Territory and Environment, Faculty of Architecture, "Sapienza" University, Rome, Italy

Abstract

The efficient use of resources requires the overall control of the flow of materials through each intervention and the closing of production cycles from *Cradle to Cradle*: reuse and recycling of CRD waste can reduce the environmental footprint of buildings. Italian reality is quite controversial: considerable amounts of waste end up in landfills, while industry often produces materials by reusing/recycling pre/post-consumer waste, as in the ceramic district in Emilia, and reclaimed components and materials are used in renovations, as in the *Alberghi Diffusi*. Such practices must be extended by developing new regulations and design tools.

Keywords:

Cradle to Cradle, CRD waste, Reuse, Recycling, Supply Chain

1 THE MANAGEMENT OF BUILDING MATERIALS AND WASTE FLOWS IN EUROPE: ENVIRONMENTAL ISSUES

The efficient use of resources is a fundamental tenet of sustainable building construction, which calls for the overall control of the flow of materials (incoming and outgoing) through each intervention. To turn this tenet into diffuse practice, it is essential to dig deep into the critical aspects of the building sector, in order to develop effective design strategies and innovative methodologies.

The building sector has a significant impact on energy and environmental resources (water, soil, vegetation) and it considerably affects mineral wealth. Through the **Roadmap to a Resource Efficient Europe** in 2011 the EU has emphasized the severe impact of the consumption of raw materials in the construction industry, which represents 50% of the excavated materials each year. The Roadmap anticipates that by 2020 'significant improvements in resource and energy use during the life-cycle – with improved sustainable materials, higher waste recycling, and improved design – will contribute to a competitive construction sector and the development of a resource efficient building stock. This requires the active engagement of the whole value chain in the construction sector' [1].

Both in new construction and retrofitting, the reuse and recycling of materials can guarantee the reduction of the environmental footprint, and in particular the embodied energy, of building components: in fact, 10-15% [2] of energy consumption in the construction sector worldwide is due to raw materials extraction.

In addition to this, Construction Renovation and Demolition (CRD) waste accounts for a great portion of the waste flow in Europe: inert waste make up one third of the entire volume of waste produced annually in EU, which means one billion tonnes per year [3]. The recycling rate for CRD waste is significant only in countries with fewer mineral resources, such as the Netherlands, and in other virtuous countries, as Austria and Germany, while in Italy is rather low. Furthermore, each country tends to concentrate on recycling specific fractions of CRD waste produced, depending on the range of techniques available locally. This generates a very differentiated and fragmentary context in which the collection and comparison of data can be very difficult (Figure 1).

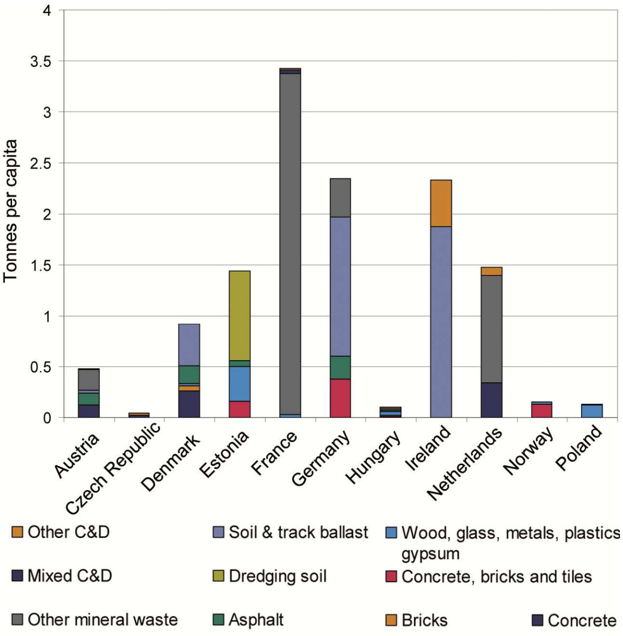


Figure 1: Recycling of specific materials from C&D waste by selected EU countries (ETC-SCP, 2009).

The aim of significantly increasing the recycling processes is stated by the **European Directive 98/2008/EU on waste**, which in Article 11 states that 'by 2020, the preparing for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 17 05 04 in the list of waste shall be increased to a minimum of 70% by weight'. The EU minimum target, if for some Member States is already achieved or at least near (Netherlands, Belgium, Germany, Austria), for Italy is particularly ambitious: the average percentage of waste diverted from landfill is in fact close to 10%, with a significant discrepancy between the central/northern regions and southern/island regions. Moreover, in the above-mentioned Directive member states are asked to promote 'high quality recycling' by increasing waste separation, which in the building sector can be translated into high quality selective demolition processes, which are still quite rare in Italy.

Finally, Article 4 states a precise hierarchy which puts prevention and reuse above all other strategies: 'the following waste hierarchy shall apply as a priority order in waste prevention and management legislation and policy: (a) prevention; (b) preparing for re-use; (c) recycling; (d) other recovery, e.g. energy recovery; and (e) disposal'. This hierarchy still tends to be disregarded all across Europe, because of legal and economic incentives which drive into recycling or energy recovering, without even trying to reclaim or reuse valuable materials. This brings to a diffuse down-cycling of components, with a great loss of energy and materials still suitable to maintain their original function or even have an updated scope. The correct integration of the above mentioned strategies, respecting their right priority with the prevalence of reuse, is the only way to obtain a positive environmental balance in a building intervention, because it allows the control of embodied energy in buildings.

In fact, in the light of the reduction of **operational energy** of buildings, obtained in Europe in recent years thanks to the spread of technological and plant solutions that enable us to create passive, Nearly Zero Energy or Energy-Plus buildings, the impact of **embodied energy** of materials and components appears more evident and severe. However, whereas the reduction of operational energy of buildings can be achieved through the improvement of energy efficiency of building envelope and facilities, addressing the challenges related to the life cycle of materials requires a complex paradigm shift, involving different segments of the building industry in an adaptation to the circular processes of nature.

The *Milestone* set by the *Roadmap to a Resource Efficient Europe* is that 'by 2020 the renovation and construction of buildings and infrastructure will be made to high resource efficiency levels. The Life-cycle approach will be widely applied; all new buildings will be nearly zero-energy (Directive 2010/31/EU) and highly material efficient, and policies for renovating the existing building stock will be in place (Art. 9, Directive 2010/31/EU) so that it is cost-efficiently refurbished at a rate of 2% per year'. This means reducing, reusing, and recycling most if not all materials that remain after construction or renovation interventions, in order to drastically reduce the amount of waste produced, while at the same time enhancing the adoption of recycled materials and reused components.

2 FROM ECO-EFFICIENCY TO *ECO-EFFECTIVENESS*: THE *CRADLE TO CRADLE* APPROACH TO PRODUCTION

The demand of virgin materials can only be reduced by closing production cycles, with an innovative materials management inspired by the ***Cradle to Cradle*** theory: based on eliminating the concept of waste, this approach suggests to go beyond the mere goal of minimizing the negative impacts of production, to a new model where production has positive impacts on the environment and on society, elevating the ambition **from *eco-efficiency* to *eco-effectiveness***. The latter is much more difficult to reach, because it is not limited to the control and reduction of the damages caused by production activities, but it represents the attempt of making industrial cycles part of natural cycles, without generating any damage but being beneficial to the environment and not only to men. To reach this goal, production must become a continuous cycle of use and reuse of materials without waste. In fact, all the major nutrients of our planet are continuously recycled in a cyclical biological system in which 'waste equals food' [4]: in this sense, all wastes are potential 'nutrients' for both the biological and the *technical* cycle. This new way of conceiving production activities elicits a shift of our point of view: producing something which is *less bad* than what we used to produce is not enough. We need to design and build things which are good for us as well as for the environment: 'thinking of design in terms of *eco-effectiveness* could represent an unprecedented innovation, or it may simply help us to optimize a system that already exists. It is not the solution itself which is radical, but rather the change of perspective, the transition from an old view of nature as something to be controlled, to a creative attitude' [4]. The imperative of closing production cycles, essential for the contemporary ecological paradigm, can only be applied with a creative effort in the philosophy of design.

Undoubtedly, since the elaboration of the *C2C* theory in 2002, given the complexity of its objectives, its experimental application has not spread extensively. However in 2009 the EU has given rise, on the initiative of the Province of Limburg (Netherlands/Belgium), to an interesting *fast-track* project, called *C2C Network*. The project lasted two years, ending in December 2011, and involved ten countries in the dissemination and implementation of the *C2C* theory. The *Network* has collected 160 case studies in different sectors, showing how in many *C2C* buildings and products in Europe, mainly in the Netherlands but also in other countries like Finland and Italy itself, the implementation of the theory has produced significant environmental, social and economic results. Among the case studies collected from the *Cradle to Cradle Network* there are 59 industrial products, 39 buildings, 30 examples of spatial area development and 32 models of governance [5].

3 THE ROLE OF BUILDING DESIGNERS IN THE ENVIRONMENTALLY CONSCIOUS SELECTION OF MATERIALS

While underlining the crucial role of recycled materials for an eco-effective architecture, it is necessary to point out the problems that hinder their spread, such as regulation inadequacies and lack of systematic and diffuse information on their potential. Nevertheless, what significantly limits the implementation of these strategies is the lack of awareness about the ecological behaviour of materials and components in the actors of the building process, in particular architects and building contractors.

To work on a progressive reduction of the demand of virgin materials in the next few years, some rules and habits in architecture and landscape design have to be changed: a conscious and responsible choice of materials and components should become a central issue of design for both new construction and energetic/environmental retrofitting of existing buildings, allowing us to drastically reduce the demand for energy and virgin raw materials and to respond to the ethical and legal obligation of closing the production cycles of building materials.

It is therefore necessary to monitor the flow of building materials in the different phases of the construction process, in order to maximize the effective use of resources, integrating ***responsible sourcing*** with the strategic practices of reuse and recycling. *Responsible sourcing* is the key strategy for a sustainable procurement of materials: it offers a holistic approach to the management of a product in its whole life cycle, from extraction of raw materials to, manufacturing, processing, use, reuse, recycling, and disposal of the final waste. It provides an ethical management of the production chain that includes social, economic and environmental principles, and addresses issues such as the involvement of stakeholders and the management of supply chains, upstream of the industrial production. However, there is still much to do in order to integrate *responsible sourcing* with reduction, reuse and recycling strategies organically in the building process.

4 INNOVATIVE TECHNIQUES FOR THE PROCESSING OF CRD WASTE

In this context, research on materials represents a field of primary importance for the optimization of building environmental performances during construction, use and demolition: by reintroducing waste as ***secondary raw material,*** it is possible to significantly lower *embodied energy* ensuring a comparable quality of components. Virtuous cases of building materials produced by **recycling pre- and post-consumer waste** arising from separate municipal collection or from the building sector itself are increasing worldwide. Recycling processes based on environmentally friendly and energy efficient processes begin to spread, as well as innovative treatments of waste from CRD. Indeed, while considerable amounts of recyclable materials still end up in landfills, the use of recycled and ecological materials is spreading worldwide, fostered by the importance that green certification systems for buildings, such as BREEAM, LEED, MINERGIE and ITACA, give to recycled content and to local sources.

Using secondary raw materials available locally ensures greater independence in the supply of resources and in some cases can even offer higher quality products. For example, consider the aggregates resulting from the crushing of concrete in their secondary use as a filling of road embankments: in this case the traces of binder which remain upon debris, due to the load, over time provide for an increased carrying capacity and stiffness of the embankment. On this issue, see the guidelines for the life-cycle of recycled aggregates produced within the European project *SARMa* [6].

Indeed, while the opportunity of reducing the number of demolitions mainly depends on each country's urban strategies and policies, the quality of the products arising from demolition depends on the accuracy of the project and on the techniques adopted, which can make a difference, by demonstrating the **technical inter-changeability of recycled materials with virgin ones**. The development of advanced selective demolition techniques and innovative recycling processes applied to CRD wastes is quite frequent in some countries, but not everywhere in the EU.

A significant barrier to the spread of the practice of recycling of demolition materials is the difficulty of treating CRD waste on site. Given the prevalence of reinforced concrete and brick in the Italian building stock, for example, the practices of deconstruction can be applied to a lesser extent than in countries like USA, where wood construction is definitely more common. Therefore, technological solutions aimed at the treatment of demolition debris on site are needed, especially in cases of refurbishment interventions, which are prevalent in Italy, where only a small percentage of demolitions address the whole building, whereas partial renovations are definitely more frequent.

A very interesting example, in this sense, is the research project *Aufbaukörnungen* of the Arbeitsgruppe Recycling, F.A. Finger-Institut für Baustoffkunde, Fakultät Bauingenieurwesen, Bauhaus-Universität Weimar. This research works on the consideration that in Germany one third of the construction waste is not recycled and that only 1% of construction waste recycled is used in building construction. Its aim is the development of a mobile construction waste treatment plant which can produce a material with definable and reproducible properties from heterogeneous, fine-grained mineral construction waste (Figure 2).

Figure 2: Mobile construction waste treatment plant made of a primary screen, an impact crusher and a magnet (<www.aufbaukoernungen.de/ziele.html> 08/12).

These innovative technologies for the improvement of recycling processes applied to CRD wastes, especially those which can be applied directly on the building site and dedicated to debris of reinforced concrete, masonry and the mixed ones, are not very common yet, but could become a key answer to the need of reducing the amount of wastes destined to landfill, by ensuring a shorter sequence of phases to the recycling process. The comparison between *in situ* and industrial treatments elicits the issue of quality verification, which is not always possible if wastes are recycled on site, but is essential to the whole eco-effectiveness of these procedures.

5 LIFE CYCLE CONTROL OF BUILDING MATERIALS: STRENGTHS AND WEAKNESSES OF THE ITALIAN REALITY

In this field, the Italian reality is quite controversial: with a building sector mainly characterized by the backwardness of processing techniques, and even of the collecting system, of CRD waste, considerable amounts of materials still end up in landfills, or are fly-tipped. A significant reason for this is the backwardness of the whole Italian building sector, which is typically rather traditional and not much industrialized.

Furthermore, the excessive consumption of non-renewable raw materials in Italy appears clear if one considers the mining industry of stone materials: there are 5,736 active quarries in Italy, with 144 million cubic meters, including sand, gravel, limestone and ornamental stone, extracted in 2010 [7]. The largest portion of materials excavated are destined to the production of cement and concrete, which is still the dominant building technology in Italy: limestone, sand and gravel make up 80% of the extracted raw materials each year.

On the contrary, industry turns out high quality building materials, often produced by recovering, reusing or recycling post-consumer waste from separate refuse collection, in particular plastic and glass or post-industrial waste, for example in the ceramic sector in Emilia-Romagna and integrating them with quality virgin materials.

A greater effort should be done in the recycling of demolition waste: almost 98% of construction projects in Italy consists in requalification and is characterized by micro demolitions, while new construction interventions as well as full demolitions are a minority. In this context, reusing and recycling materials on site could allow closed loop interventions, as it happens usually in the restoration of historical buildings. The same strategies would provide the opportunity to operate on existing buildings for energy-environmental retrofit, rehabilitation, consolidation and aesthetic improvement, in a widespread and environmentally friendly way, and have a specific potential in the Italian reality.

5.1 Green manufacturing processes: the ceramic sector in Emilia-Romagna

Italy has a very strong and renowned ceramic industry: in 2011 there were 163 ceramic tile manufacturers operating, which produced about 400 million square metres of tiles. Environmental safety and quality have long been amongst the key objectives of the Italian ceramic industry, which was the first in the world to address these issues. Owing to its rapid development over the past thirty years and the high geographical concentration of companies, it has become necessary to adopt new measures for limiting environmental impact. The analytical tools and environmental policies were initially focused on 'end of pipe' pollution control (i.e. limited to reducing the effects on the environment without addressing the underlying causes) and have now been superseded. Today the Italian tile industry is at the forefront of research into technologies, raw materials and processes for reducing the impact of production activities on the environment and humans.

In environmental terms, the production phase is the most relevant segment of the life cycle of a ceramic product. The environmental issues associated with manufacturing are: gaseous emissions, energy consumption, water consumption, discharges of wastewater and waste generation. Because of the strong geographic concentration which characterizes the provinces of Modena and Reggio Emilia, the so called **Ceramic cluster**, this area suffers a multiplication of environmental effects which has led it to take a serious strategic path towards a practical application of the principles of sustainable development.

Ceramic industry has, in particular, tried to reach the full reuse of its waste, to reduce water withdrawals and emissions and to maximize the eco-efficiency of its productive processes. The concentration of industries in manufacturing districts has encouraged the application of effective control measures, thanks to territorial proximity and to competition between individual companies: this has helped achieving significant results, documented in reports with the collaboration of sector research centres and laboratories such as the CCB (Ceramic Centre of Bologna).

Following the introduction of internal or inter-company recycling systems, 90% of companies no longer discharge waste water. Thanks to innovations introduced for promoting energy saving, since the 1980s the sector has also gradually reduced its production of carbon oxide, which has now stabilised at the levels of 1970 when output was half the current figure. Since 2009 an *Emissions Trading Agreement* is in force in the ceramic cluster: a new system of authorized "quotas" which can be traded between businesses to progressively reduce the ceramic industries' emissions into the atmosphere.

Besides reducing average waste production, techniques have also been introduced to allow very high percentages of waste to be reused in the sector, in some cases almost 100%. An integrated report about the ceramic cluster of Sassuolo-Scandiano in 2008 provides an interesting picture of the flow of recycling and reuse of waste and production residues in the district: almost all the factories recycle almost all waste production and water treatment, both internally and externally. In particular, **reuse reaches 100% for unfired and fired waste**, which represent the main production waste, and about 25% of the waste of purification (exhausted lime).

Specific research projects concerning possible uses of waste from the ceramic industries in other productive processes are being developed in the same district. A good example is an experiment, conducted by CCB with the Italian industry MAPEI within the laboratory CerPosa in 2011, on how to grind the fired waste deriving from the production of tiles in the proper way to replace the sand in the mortar used for the laying of the tiles themselves [8].

So, the Italian ceramic industry strives to combine environmental protection, safety and health with the maintenance and development of its international competitiveness. In recent years, voluntary certifications spread in the whole productive sector, through the application of comprehensive and integrated standards and regulations, such as Ecolabel, ISO 14001, EMAS, and specific LEED guidelines for producers, which marked a profound change in the corporate management.

LEED guidelines for ceramic tiles were prepared by Confindustria Ceramica in collaboration with the Ceramic Centre of Bologna, Habitech - Technological District of Trentino and the LEED Work Group. They provide a selection of the significant credits for ceramic products and a key to the relevant parameters and represent a useful instrument for company technicians who need to reply to the technical questions, which are asked more and more frequently by distributors and designers to manufacturing companies; furthermore they represent a valid support for the qualification of a company's products within the rating system.

Similar LEED guidelines have been developed in Italy for other building materials industries: for doors and shutters (by UCCT, member of the EDSF - European Door and Shutter Federation, and Habitech), for thermal insulation made of rigid polyurethane foam (by ANPE and Habitech) and for wood furniture (by FEDERLEGNO and Habitech). These guidelines are helping the spread of this voluntary certification for green buildings in Italy, where in 2009 the Green Building Council has introduced a specific national protocol, and where about 60 buildings have obtained the LEED certification in just a few years. Nonetheless, it is important to notice that only 7% of LEED certified buildings in the U.S. have so called *reuse credits*, and very few exploit the credits concerning regional materials, due to the large distances which characterize the American country. On the contrary, Italy has a great potential for working on local supply chains.

5.2 Design for reuse of existing buildings and materials: the *Alberghi diffusi* in Basilicata

The instability which followed the outbreak of the American housing bubble has recently led to a greater attention to the requirements of quality and durability in the building sector. As a matter of fact, a commodity destined to early obsolescence risks to be not just ecologically but socially and economically harmful. In this sense, by choosing building materials we should mainly consider their environmental compatibility and durability, instead of focusing on aesthetic or economic aspects.

Furthermore, Italy owns a significant built heritage, characterized by complexity and stratification, which at the same time suffers a widespread inadequacy with respect to housing requirements. This context imposes a major breakthrough: the challenge of renovation, which must be conducted with the above mentioned environmental issues concerning materials in mind.

As a matter of fact, Italy has a relevant tradition in the restoration of historical buildings, where great attention has always been paid to the reuse of components and materials, aiming at reaching the highest compatibility of original elements with restored ones, which could inspire new experiences applied to more modern assets.

Significant examples of **renovation of entire villages through the reuse of old buildings and local materials** can be found in Italy in the so-called ***Alberghi Diffusi***. This new form of hospitality, whose main components are distributed in different buildings, all located in the same village or town, satisfies the tourists' demand of staying in contact with residents and local people rather than only with other tourists. The term 'diffuso' (diffuse) denotes a structure that is horizontal, and not vertical like the one pertaining to traditional hotel buildings. At the mean time, this form of hospitality has showed to be very efficient in enhancing towns and villages that are artistically or architecturally peculiar and interesting, through the renovation of old, dismissed buildings. This also helps solving the problem of hospitality without building new structures.

The concept of *Albergo Diffuso*, first applied in Santo Stefano di Sessanio, in the Italian region of Abruzzo by Daniele Kihlgren, has recently been transferred to Basilicata, by the Sassi of Matera and by the Civita Grottos, where it has helped protecting a unique architectural and cultural heritage.

The Sassi of Matera represent a unique historical town centre, carved out entirely from chalk stone. The traditional dwellings are caves excavated in the sloping wall of a deep ravine and date back, originally, to the Neolithic era. In the 1950s, after being inhabited for decades despite malaria and poor hygienic conditions, the Sassi were abandoned due to their neglected condition and because they were considered an evident example of the under development of Southern Italy. They became property of the state and walls were erected to prevent them from being occupied, but this stopped natural ventilation leading to rapid degradation. The rehabilitation of the Sassi began in 1986, with an intervention of the Italian Government, followed in 1993 by the inscription as an UNESCO World Heritage Site, also thanks to the proposal written by a local architect, Pietro Laureano [9].

Matera became a destination for both national and international tourists and the individual requests to return and live in the Sassi multiplied. They were equipped with a network of water systems, drains, gas, electricity and telecommunications, whose cables were buried in underground trenches so not to disturb its architectural qualities or the landscape. Around 3,000 people live in the typical cave-homes today, while some grottos have been turned in *Albergo Diffuso*.

The *Albergo Diffuso* of Civita is located in the grottos which had been excavated in the cliffs of the Gravina River, facing the Murgia Park with its rock churches (Figure 3). Occupying the oldest and poorest part of the Civita, which degrades towards the river bed, the AD takes up three different levels, connected by staircases and terraces and comprises eighteen rooms/grottos, each one with its own access through a small garden with a view upon the Murgia Park.

Figure 3: Civita Grottos, partially excavated in the sloping wall of the ravine on the Gravina River, Basilicata,Italy.

These assets are particularly well integrated with their territory, because at the time they were built poverty and lack of resources forced to choose local materials, with their patterns and colours clearly belonging to the original topography of the area. These buildings interpret in a very immediate way the *genius loci* and should be protected with conservation and reuse strategies which can prevent the visual pollution that could be caused by the extraneousness of materials and technologies, such as those used during the second half of the last century.

In the restoration of the old grottos, designers have had recourse to **salvaged materials and objects**: furniture has been limited to the essential pieces, in order to avoid interfering with the dramatic materiality of these places, as for example household linen which has been reclaimed from old trousseaus (Figure 4).

Figure 4: Interior of the Albergo Diffuso in Civita: both materials and furniture have been locally reclaimed.

The conversion of the grottos in hotel rooms can be considered as an up cycling of the original function of the caves, which brings benefits not only to the architectural heritage, but also to the population, generating a work activity out of the specific features of the site. Local identity is no longer seen as limiting, but as a value to be preserved.

This new approach of Conservative Restoration of minor heritage is enhancing many small Italian villages which were wasting away under the weight of time and neglect, and were threatened by speculation.

6 ACTIONS AND INSTRUMENTS FOR THE PROMOTION OF A SUSTAINABLE MANAGEMENT OF WASTE IN ITALY

Drawing inspiration from these positive experiences, new instruments could be developed to help Italy reach the above mentioned targets. The actual application of sustainable management of waste in Italy calls for five main actions:

- Enabling a greater awareness of the actual situation of CRD waste in the country by helping to understand: **the composition and causes of waste, the typical wastage rates of different materials, the financial and the environmental cost of waste**, which includes the impacts associated with manufacturing and distributing the wasted products, e.g. embodied energy, which is usually far greater than the subsequent impacts associated with managing the waste material, especially if it is reused [10].
- Updating, tightening and implementing the **regulations for the management of CRD waste** and, more broadly speaking, **for *responsible sourcing* and procurement of materials** in the building sector, in particular **landfill taxes or bans**: this would increase the cost of waste management, forcing building companies to prevent waste. In this sense, very positive models are British laws such as the *Smart Waste Management Plan, Landfill Tax* and *Aggregate Levy*.
- Encouraging **supply chain partnerships and agreements,** in order to promote environmental improvements as those achieved in the ceramic cluster in Emilia; promote collaborations between different industrial sectors, in order to systematize the resources and turn one's waste into another's raw material.
- Revising Italian **technical specifications** by updating performance requirements to the account of ecological features and in particular of *secondary raw materials*, in order to get operators to understand the environmental and technical values of reused and recycled materials, thus helping a wider acceptance of *secondary raw materials*.
- Developing and spreading **specific tools for building designers** specifically conceived to support the implementation of the strategies of reduction/reuse/recycling.

In the fragmentary Italian situation, in fact, new instruments, such as web-based software, tools or databases, could help matching demand and supply and facilitating the dialogue between designers, builders and producers. Reuse and recycling strategies require a major effort in finding materials and in the recognition of local resources, both through direct search of the territorial sources and through the help of new tools such as online platforms, already quite widespread in the U.S. and U.K., which act as a place of exchange, mainly at a regional level, for building materials resulting from construction or demolition. These platforms give the unique opportunity to match many users and resources distributed widely at the local level, allowing an exchange otherwise impossible.

Significant examples of platforms for the exchange of reclaimed reusable materials and building components, whose purpose is to facilitate reuse through an easy access to data and ads, are the British SALVO (Figure 5), active as a directory since 1991, and the web portal of the U.S. brokerage company *Planet Reuse*. This company, run by LEED AP Nathan Benjamin, thereby offers support to designers and users interested in obtaining LEED certification, especially for the credits of the area *Materials and Resources*.

Figure 5: Storage of salvaged materials from buildings subject to partial/total demolition and manual removal techniques, sold by dealers who adhere to the British network SALVO (Salvo Fair 2012, Maidenhead, UK).

Other indispensable tools which can help designers dealing with the complexity of technological design based on reuse/recycle are assessment methods and choice backups. In this sense, it would be very useful to transfer the *C2C* certification system from the scale of the product to the whole building: this certification, which raises the thresholds of tolerance far beyond compliance with regulatory limits, is particularly difficult to apply to the whole building and elicits a specific variation. Moreover, tools supporting the design process should be developed as, for example, software for predicting the outcome of selective demolition, allowing the evaluation of ecologic and economic sustainability of different scenarios, with different techniques and outputs. An interesting example is the online tool *Smartwaste* developed for the United Kingdom by BRE [11].

In Italy, due to the inertia of the building sector, these tools are struggling to spread, making it even harder to implement the above-mentioned strategies. Nevertheless, this is certainly the only path which can help building designers and contractors turn *Cradle to Cradle* strategies into real actions.

7 REFERENCES

[1] EU COM/2011/0571.

[2] UNEP (United Nations Environment Programme), 2002, Annual report *Buildings and Climate Change.*

[3] European Commission, Joint Research Centre, Institute for Environment and Sustainability, 2011, *Supporting Environmentally Sound Decisions for C&D Waste Management – A practical guide to LCT and LCA*.

[4] Braungart M., McDonough W., 2002, *Cradle to Cradle: remaking the way we make things*, North Point Press, New York.

[5] <http://www.c2cn.eu/> (07/12).

[6] <http://www.sarmaproject.eu/> (04/12).

[7] Legambiente, 2011, *Rapporto cave.*

[8] <http://www.cencerbo.it/> (07/12).

[9] Laureano P., 1993, *Giardini di Pietra, i Sassi di Matera e la civiltà mediterranea*, Bollati Boringhieri, Torino.

[10] Hobbs G. (edited by) 2011, *Construction Waste Reduction around the World - CIB Publication 364,* Working Commission W115 Construction Materials Stewardship.

[11] <http://www.smartwaste.co.uk/> (08/12).

Translate the Cradle to Cradle Principles for a Building

B. van de Westerlo[1], Johannes I.M. Halman[1], E. Durmisevic[1]
[1]Faculty of Construction Management and Engineering,
University of Twente, Enschede, The Netherlands

Abstract
Various guidelines for Cradle to Cradle in the built environment were established since 1992. However, it's not clear how the Cradle to Cradle principles can be translated to the realization of a building. This paper contains information from literature with a focus on applying the Cradle to Cradle principles in building design and -construction. Also results of interviews with experts and directly involved stakeholders, about applying the Cradle to Cradle principles in the built environment will be provided. Specifically a number of aspects and desired results will be addressed, which seem to be essential in the realization of a building.

Keywords:
Cradle to Cradle, building, eco-effectiveness, continuous cycle, built environment

1 INTRODUCTION

For several decades there has been a discussion in the scientific literature about sustainable development in the built environment. Even today there is still a lot of confusion about what sustainable development really means, and how developments in this category are interrelated. The same applies to the more recent Cradle to Cradle approach. In the book Cradle to Cradle, Remaking The Way We Make Things, an approach is introduced that distinguishes biological- and technological cycles without quality loss of raw material [Braungart and McDonough, 2002]. Residues become raw materials for a subsequent metabolism. By distinguishing biological - and technological material cycles, Cradle to Cradle introduced a unique form of closing material cycles, with the elimination of waste.

Braungart and McDonough have defined three basic principles that are essential to make a true transition towards sustainable society. The following three basic principles are being applied:

1. Waste equals Food, Everything is a Nutrient for Something Else;
2. Use Current Solar Income, Energy that can be Renewed as it is Used;
3. Celebrate Diversity, Species, Cultural and Innovation Diversity.

Various guidelines for Cradle to Cradle in the built environment were established since 1992 through published declarations such as the Hannover Principles and more recently in The Netherlands, the Almere Principles and the Floriade Venlo Principles.

The Cherry Tree is often used as a metaphor for a Cradle to Cradle building: Imagine buildings that harvest the energy of the sun, sequester carbon, make oxygen, distill water, provide habitat for thousands of species as well as generate more energy than they consume.

However, it's not clear how the Cradle to Cradle principles can be translated to the realization of a building. Specifically, in this paper a number of criteria that seem to be essential in the design and realization of a building will be addressed. The findings of this paper result in a further concretization of the Cradle to Cradle principles into aspects and desired results for the design and realization of buildings. This paper focuses on the Cradle to Cradle development and implementation in the built environment in the Netherlands.

2 LITERATURE

Warnings have been sounded around the world since the 1960s about the deterioration of the environment. Partly because of these warnings, numerous proposals have been made from the 1960s onwards for a worldwide approach to existing and predicted environmental problems. The first examples of these are the World Conservation Strategy by the International Union for Conservation of Nature (IUCN) in 1980, and the Brundtland Report by the World Commission on Environment and Development (WCED) in 1987. Both reports advocate a departure from non-sustainable consumption and production in favor of sustainable development. The Brundtland Report defines sustainable development as a form of development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Since then, awareness of the global environmental problems has clearly increased. Among the results has been the formation of a number of lines of thinking aimed at contributing to the reduction – and ideally the complete elimination – of environmental problems. Figure 1 gives a chronological overview of important schools of thought in relation to sustainable development. The timeline also refers to major environmental disasters in the same period.

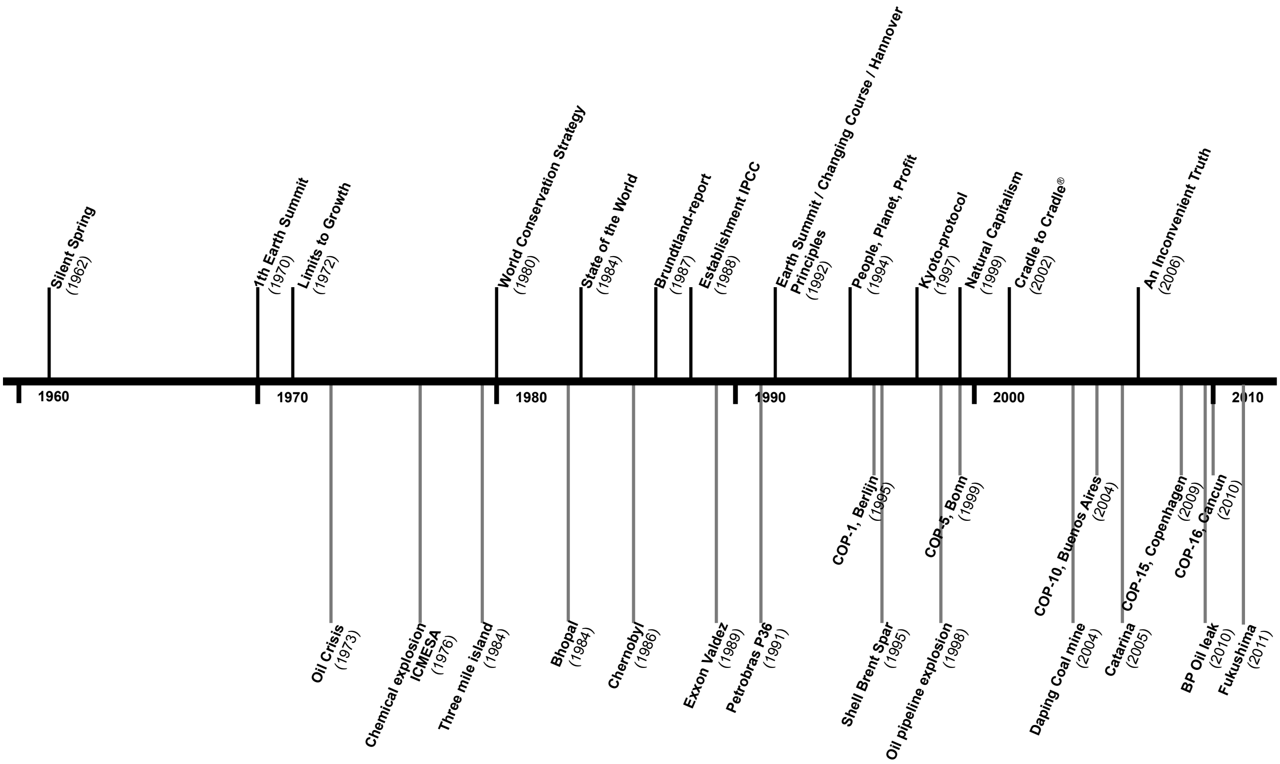


Figure 1: Overview of important schools of thought in relation to sustainable development, including major environmental disasters.

2.1 From eco-efficient towards eco-effective and eco-efficient sustainable development

Following the Earth Summit in Rio de Janeiro (1992), the question arose of what the possible contribution of industry could be to achieving sustainable development. Eco-efficiency aims to reconcile environment and economy by producing more from less: using minimal resources to work at lower cost and in a more environment-friendly way. The core of eco-efficiency can be summarized as: 'get more from less'. More products or services with less waste, less use of materials and lower harmful emissions.

After this Earth Summit, fifty of the world's largest companies analyzed the applicability of the concept of sustainable development. In the book Changing Course, these companies introduced a strategy to achieve this sustainable development. This strategy followed an eco-efficient approach, defined as companies that continuously create more usable products and services – that add value – while also continuously reducing the consumption of resources and the production of emissions [Schmidheiny, 1992]. In line with the above definition, the World Business Council for Sustainable Development (WBCSD) investigated the application of eco-efficiency in industry and reached the following definition: eco-efficiency is achieved by the delivery of competitively-priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the earth's estimated carrying capacity [WBCSD, 2000]. Based on the strategy of eco-efficiency, innovative strategies have been developed focusing on reduction and compensation of harmful effects on the environment.

Out of concern about the lack of completeness of the concept of eco-efficiency, McDonough and Braungart came up with a response with the introduction of the concept of eco-effectiveness in 2002. Eco-efficiency delays environmental pollution and the exhaustion of natural resources. An eco-efficient approach would allow the use of fossil fuels to be minimized, but it will never be possible to eliminate their use completely. A total solution requires a new paradigm. Simply reducing the problem will never solve it completely, and will also limit freedom of trade and growth opportunities. Less bad is still not good, according to McDonough and Braungart. Eco-effectiveness is based on a continuous-cycle approach, in which materials are used in new products, processes and objects in a way that they are 100% recyclable or even upcyclable, and in which the energy for all activities must be renewable. Eco-effectiveness causes no adverse effects in relation to a sustainable development. To work effectively towards sustainability, an eco-effective approach is essential to achieve positive effects in a range of areas. A certain level of eco-efficiency can certainly be valuable in an effective system. Eco-efficiency can also be valuable as a transitional strategy towards an eco-effective system.

2.2 Application of the Cradle to Cradle approach in the built environment

The past decades have seen repeated scientifically based warnings about the deterioration of the environment. A number of scientific studies have by now made it clear that – with 90% certainty – greenhouse gas emissions resulting from human actions are having a negative impact on the environment. As a reaction to these warnings, numerous initiatives have been taken around the world to achieve sustainable development.

As far as the built environment is concerned, these initiatives have focused primarily on finding alternative solutions for ways to generate- and use energy, the selection and use of resources and materials, and the development and implementation of alternative principles in the design of buildings.

The application of the Cradle to Cradle principles however would require a paradigm shift in the way designers, builders and owners understand the future value of the building and materials, as well as ownership and life cycle processing. The application of the Cradle to Cradle principles and an eco-effective approach in the built environment is taking off very slowly. One important reason for this is the lack of government policy to promote the use of materials in continuous cycles, without harmful effects on the environment. There is also still a lack of awareness in the building industry of ecological and/or economic aspects (see e.g. European Commission, 2010). These are important prerequisites for the successful implementation of the continuous-cycle principle in the building industry. A third factor is the lack of design knowledge and experience, and possibly also the will, to design a building based on the needs of the user that meets the Cradle to Cradle requirements. This would mean a design of a building that can be adapted or deconstructed with full re-use of the materials (of which it is made), and in which the energy supply is based on renewable energy, and has value for the stakeholders.

To make these changes in the building process, a change in the mindset of designers is the most important requirement. As William McDonough says: We need to take the filters from our pipes and put them in our designers' heads (McLennan, 2004).

2.3 Cradle to Cradle Criteria for the Built Environment

The various guidelines for Cradle to Cradle in the built environment, such as the Hannover Principles, Almere Principles and Floriade Venlo Principles, give direction to the implementation of Cradle to Cradle principles in practice, but will only be effective when they can be measurably demonstrated.

In 2010, Mulhall and Braungart introduced Cradle to Cradle criteria for the built environment. The following definition of a Cradle to Cradle building is given: A Cradle to Cradle building contains defined elements that add value and celebrate innovation and enjoyment by: measurably enhancing the quality of materials, biodiversity, air, and water; using current solar income; being deconstructable and recyclable, and performing diverse practical and life-enhancing functions for its stakeholders [Mulhall and Braungart, 2010]. The three basic principles of Cradle to Cradle and the definition of a Cradle to Cradle building have been translated into criteria for the built environment by Mulhall and Braungart (Table 1).

A critical note that should be made is, that based on the criteria in table 1, it will not be possible to determine to what extent a building meets the Cradle to Cradle principles. A first reason is the lack of a practical and specific expression of the Cradle to Cradle principles for a building. Without such a concretization it is not possible to make an informed decision whether a building is, or is not, designed according to the Cradle to Cradle principles. The criteria are more general guidelines and recommendations that can be used during the design and realization of a building, whereby it is unclear whether a building complies the Cradle to Cradle-principles or not.

It is also unclear to which qualities or quantities a building can be measured. How can be demonstrated if a building meets the Cradle to Cradle principles? These observations have given rise to the practical translation of the Cradle to Cradle principles for a building.

3 METHODOLOGY

In the first phase, an inventory was made of the most important aspects, that are appointed in literature, to realize a building according to the Cradle to Cradle principles. The literature survey focuses on the period from 1992 to 2012. The Hannover Principles: Design for Sustainability, were formulated in 1992 by McDonough and Braungart as development guidelines for the World Expo 2000 in Hanover. Studies on the application of the Cradle to Cradle approach has frequently occurred in recent years. Different contributions are presented in publications by McDonough and Braungart (1992, 2003a, 2003b, 2006, 2009) and Mulhall and Braungart (2010). Developments in the Netherlands are presented in publications of Build Desk (2009), Royal Haskoning (2009), SenterNovem (2009), Ministry of Transport, Public Works and Water Management (2010), Delta Development Group (2010) and TNO Building and Construction (2010).

Secondly, interview sessions with nineteen professionals in the field of Cradle to Cradle applications were conducted. The respondents were asked to reflect on their experiences with implementing the Cradle to Cradle principles in practice and what they considered as the main challenges for realizing a building in line with the Cradle to Cradle principles. Besides being experienced in the design and building process, respondents satisfied at least one of the following criteria:

- Has successfully completed an official Cradle to Cradle training, or;
- Is Cradle to Cradle Certified Consultant, or;
- Is sustainability manager at a company that produces or markets Cradle to Cradle Certified products, or;
- Participates in a building project with defined Cradle to Cradle ambitions.

Table 1: Criteria for the built environment based on the defining Cradle to Cradle Principles.

C2C Principle	Criteria
Waste = Food, Everything is a Nutrient for Something Else	Define Materials and Their Intended use Pathways
	Integrate Biological Nutrients
	Enhance Air and Climate Quality
	Enhance Water Quality
Use the Sun, Energy that can be Renewed as it is Used	Integrate Renewable Energy
Celebrate Diversity, Species, Cultural, and Innovation Diversity	Actively Support Biodiversity
	Celebrate Conceptual Diversity with Innovation

The literature study and interviews resulted in a further concretization of the Cradle to Cradle principles for a building and the development of a framework with aspects and desired results that seem to be important to realize a building according to the Cradle to Cradle principles.

4 RESULTS

In this section the identified aspects will be translated into desired. A result is considered as a desired outcome of the defined aspect. The aspects and results that seem to be important to realize a building based on the Cradle to Cradle principles are summarized in table 2. The aspects can be used to provide guidance to design- and construction teams to gain focus by the implementation of the Cradle to Cradle principles into practice.

According to professionals there is a need to translate the Cradle to Cradle principles into practice, by developing practical guidelines for the built environment. These guidelines should give direction to the decision making process in both the design and realization process.

4.1 Aspects based on C2C-Principles 1: Waste equals Food

Consider aspect 1; define materials and their intended pathways. From a Cradle to Cradle perspective, materials and products are conceived for either a biological- or technological pathway. A product or material can be analyzed based on the Cradle to Cradle Design Protocol to define the quality and content from manufacturing through use and recovery. These analyzed products and materials are selected for application in a building. The use of recycled or renewable content is only desirable when the quality and content of materials are defined. Cradle to Cradle assumes recycling in case the reuse of raw materials has positive impacts on the environment without loss of quality; nutrients become raw materials for something else. Finally, products and materials need to be selected based on their intended use and impact for the users and the surrounding.

The second aspect concerns the integration of biomass production in a building, landscape or spatial plan. From an eco-effective point of view, a building has a positive impact on it's surrounding. Biological nutrients can be integrated to generate more biomass, topsoil and clean water than before the development of the site.

Enhance both the quality of air and water are complementary, and follows from the Waste equals Food principle of nature's design. A building should measurably improve outdoor air quality, so the air becomes healthier than before development and uses climate changes gasses as nutrient. Also, a building enhances interior air quality to provide a healthy and comfortable climate for occupants and users. The building will measurably improve the quality of water, so the water becomes healthier for biological metabolisms than before it entered the building.

4.2 Aspects based on C2C-Principles 2: Use the Sun

Nature thrives on the energy of the sun. Despite recent warnings and developments, human energy systems can hardly be called effective. The Cradle to Cradle approach is based on current solar income. Forms of renewable energy are wind, geothermal, biomass (as long it has no adverse effect on the foods supply), hydropower, and solar energy. To create a positive impact on the environment, the building and its site should generate more renewable energy than the building uses. Energy-efficiency can be used to introduce renewable energy rather than reducing the use of fossil fuels; exergy can be used as a way to guide energy effectiveness. In case a building and its site can not meet the energy demand with renewable energy sources, the possibility should remain to integrate innovative solutions in the near future to work towards an energy positive building. Monitoring the energy consumption and –production of renewable energy can be used for further development towards the defined goal.

4.3 Aspects based on C2C-Principle 3: Celebrate Diversity

Healthy ecosystems are complex communities of living things. When a building is realized according to the Cradle to Cradle principles, it should be tailor designed to maximize the added value on the surrounding. Consider the aspect of actively supporting biodiversity. This aspect can be described as a building that supports more species diversity than before development. A second form of diversity that can be distinguished is conceptual diversity. Conceptual diversity can be demonstrated by focusing on special beneficial features of a building and integrating innovative elements that are beneficial for the well being of occupants and the environment.

Buildings that are designed based on the Cradle to Cradle principles have positive impacts on it's surrounding and stakeholders. This can be achieved through a description of what Cradle to Cradle elements practically do for the users and stakeholders.

4.4 Other appointed aspects

From both the literature as well as the interviews can be concluded that, in addition to the principle criteria, at least four aspects seem to be important to realize a building according the Cradle to Cradle principles. Firstly, organize *reverse logistics* of defined products and materials, whereby a material pool is developed with diverse industries. Hereby, materials can safely return to a biological- or technological cycle after the use-time or lifecycle without quality loss. To create continuous metabolisms, the building should be adaptable and deconstructable from use through recovery without demolition waste, also known as *Designed for (Dis)assembly*. Therefore, a plan to deconstruct building elements, products and materials is necessary. During the use-time of a building several transformations are made or functions will change. A study of Brand [1994] shows the number of times that materials and systems are adjusted during the use-time of a building. Brand suggests that during the use time of a construction the facade will be adapted at least once, while the furniture is replaced up to seven times. To safely return all products and materials in a biological- or technological pathway, the intended *use-time* of the building, product and material has to be defined. A fourth aspect that seems to be important in realizing a building according to the Cradle to Cradle principles is enhancing *environmental qualities*. How can a building have a measurable positive impact on the surrounded area? Through the realization of a building, the quality of the surrounding is healthier than before predevelopment conditions.

Table 2: Aspects and desired results that seems to be important by realizing a building.

	Aspects and Desired Results
Waste equals Food	**1. Define materials and their intended pathways**
	1.1 Materials and products can safely return in a biological- or technological pathway, without quality loss;
	1.2 Cradle to Cradle Certified Products and Materials are applied in the building;
	1.3 Material contents come from renewable or recycled materials;
	1.4 The design- and construction team assessed applied products and materials in the building on their intended use and impact for its users and the surrounding.
	2. Integrate Biomass Production
	2.1 More biomass, topsoil and clean water is generated by the building than before the development of the site.
	3. Enhance Air and Climate Quality
	3.1 The outdoor air quality is improved by the building so the air becomes healthier than before development and climate change gases are used to produce biomass;
	3.2 The indoor air quality is healthy and comfortable for occupants and users.
	4. Enhance Water Quality
	4.1 The quality of water is improved by the building and healthier than before it entered the building;
Use the Sun	**5. Integrate Renewable Energy**
	5.1 More renewable energy is generated by the building and it's site than the building uses;
	5.2 Energy-efficiency is used to introduce renewable energy rather than reducing fossil fuels;
	5.3 Exergy is used as a way to guide energy effectiveness;
	5.4 Innovative techniques to produce renewable energy are integrated;
	5.5 A monitoring system that measures the energy consumption and -production is used.
Diversity	**6. Biodiversity**
	6.1 Biodiversity is increased by the building.
	7. Conceptual Diversity
	7.1 Innovative elements of the building are beneficial for the well being of occupants and the environment.
Other appointed Aspects	**8. Organize Reverse Logistics**
	8.1 Supply and discharge of defined materials and products is organized.
	9. Design for (Dis)Assembly
	9.1 A plan to deconstruct building elements, products or materials without demolition waste is made;
	9.2 The building can be adapted without demolition waste.
	10. Define Intended Use Periods
	10.1 Intended Use Periods of the Building, Products and Materials are defined.
	11. Enhance Environmental Qualities
	11.1 The building improves the quality of the building surrounding;
	11.2 The quality of the Top Soil is improved by the building (including green roofs).

5 DISCUSSION

The previous sections have outlined the development of increasing attention for the Cradle to Cradle implementation in the built environment. The Cradle to Cradle approach takes an important step towards the transition from a linear to a cyclic system of resource use, without adverse effects for the environment. To grow towards sustainability, an eco-effective approach is essential to achieve positive effects in a range of areas. A certain level of eco-efficiency can certainly be valuable when it is implemented in an effective system. Eco-efficiency can also be valuable as a transitional strategy towards an effective system. However, the application of eco-effectiveness and the continuous cycles principles takes off very slowly in the built environment. One important reason is the lack of knowledge about the application of the Cradle to Cradle principles into practice. If eighty percent of the negative consequences on the environment can be foreseen in the early design stage [Thackara, 2005], the practical translation of the Cradle to Cradle principles can play a fundamental role in the design- and realization of buildings with positive impacts on the environment.

In this paper a practical framework is developed that translates the Cradle to Cradle principles for the design and realization of a building. In 2010, Mulhall and Braungart introduced a first attempt to translate the Cradle to Cradle principles in criteria for the built environment. The proposed approach contributes in the transition of the building industry towards continuous material cycles without quality loss and the use of renewable energy only. However, based on the defined criteria, it will not be possible to determine whether a building is designed and build according to the Cradle to Cradle principles. Without such a concretization it is not possible to make an informed decision whether a building is, or is not, designed according to the Cradle to Cradle principles. These observations have given rise to the practical translation of the Cradle to Cradle principles for a building. An inventory of literature and interviews with professionals show that the defined guidelines and recommendations of Mulhall and Braungart are a first step towards building criteria, but requires a further practical translation.

Therefore, the Cradle to Cradle principles are concretized in a framework with aspects and results that should guaranty desired design and construction outcomes when developing a building. However, based on the described aspects and desired results, it is still impossible to indicate whether the building is designed or build according to the Cradle to Cradle principles. When does a building complies with the described aspects and desirable outcomes? In further research we will translate the described aspects and results into performance indicators and measurable units. A measurable unit is a dimension, size or quantity of the concerned result related to the Cradle to Cradle principles.

In further research, case studies will be used to analyse to what extent they meet the aspects and desired results. The new City Hall Venlo (the Netherlands) will be used as one of the case studies. The design of City Hall Venlo is inspired by the Cradle to Cradle principles. The purpose of further research is to investigate to what extent the framework is seen as accurate, complete and practical in the design and construction of a building.

To determine whether a building complies with the Cradle to Cradle principles is just a first step. Further on the implementation of the aspects into practice is a second important step. Subsequently a strategy will be developed and tested to integrate and implement the aspects and desired results in the design- and building process.

6 REFERENCES

[1] Braungart, M., McDonough, W., 2002, Cradle to Cradle: Remake The Way We Make Things, New York, North Point Press.

[2] Braungart, M., McDonough, W., 1992, The Hannover Principles, Design for Sustainability. Charlottesville, McDonough and Partners.

[3] Feddes, F., Duijvesteijn, A., 2008, The Almere Principles, Bussum, Uitgeverij Thoth.

[4] Regio Venlo, 2009, The Venlo Floriade Principles, Venlo, Drukkerij Knoops.

[5] Westerlo, B. van de, 2011, Sustainable Development and the Cradle to Cradle-Approach, Venlo, Océ Technologies.

[6] IUCN, 1980, World Conservation Strategy, Switserland, Union for Conservation of Nature and Natural Resources.

[7] WCED, 1987, Our Common Future, Oxford, Oxford University Press.

[8] Johnson, S.P., 1993, The Earth Summit, Dordrect, Kluwer Academic.

[9] Schmidheiny, S. 1992, Changing Course, London, MIT Press.

[10] WBCSD, 2000, Eco-Efficiency: creating more value with less impact, Switserland, WBCSD.

[11] Metz, B., et al., 2007, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, Cambridge University Press.

[12] European Commission, 2010, Critical raw materials for the EU, European Commission Enterprise and Industry.

[13] McLennan, J.F., 2004, The philosophy of sustainable design, ECOtone publishing company.

[14] Mulhall, D., Braungart, M., 2010, Cradle to Cradle for the Built Environment, Venlo, Knoops Eco-Printing.

[15] McDonough, W., Braungart, M., 2003a, Towards a sustaining architecture for the 21st century.

[16] McDonough, W., Braungart, M., 2003b, Applying the principles of green engineering to Cradle to Cradle design.

[17] McDonough, W., Braungart, M., 2006, Cradle to Cradle design: creating healthy emission.

[18] Braungart, M., McDonough, W., 2009, Cradle to Cradle Building Charter.

[19] Hoogers, A., Veldhuisen, S., 2009, Ontwerprichtlijnen volgens de Venlo Floriade Principles.

[20] Royal Haskoning, 2009, Leading by Example

[21] SenterNovem, 2009, De Cradle to Cradle kaart voor de bouw.

[22] Ministry of Transport, Public Works and Water Management, 2010, Ambities vernieuwing Rijnstraat 8.

[23] Delta Development Group, Volker Wessels, Reggeborgh Group, 2010, Towards A Cradle to Cradle Park 20|20.

[24] TNO Bouw en Ondergrond, 2010, Aanzet tot C2C gebouwprestatiecriteria.

[25] Brand, S., 2004, How Buildings Learn: What happens after they’re built, Viking Press.

Eco-Sandwich Wall Panel System, the Sustainable Prefabricated Wall Panel System Made of Recycled Aggregates

I. Banjad Pecur[1], N. Stirmer[1], B. Milovanovic[1], N. Bijelic[1]
[1]Department of Materials, Faculty of Civil Engineering,
University of Zagreb, Zagreb, Croatia

Abstract
This paper presents the life cycle analysis of the ECO-SANDWICH wall system, an innovative ventilated prefabricated concrete wall panel with integrated mineral wool insulation allowing very low energy design and retrofit of buildings. The purpose of this research and development of the ECO-SANDWICH is to encourage the reuse and recycling of construction and demolition waste as well as to reduce utilization of natural resources. The substitution of conventional thermal insulation materials by Ecose® based mineral wool produced using innovative and sustainable technology leads to additional environmental benefits through the reduction of embodied energy, embodied carbon and production of by-product wastes.

Keywords:
building envelope, prefabricated concrete wall panel, recycled aggregates, life cycle analysis, Ecose® based mineral wool

1 INTRODUCTION

Construction and demolition waste (CDW) has been identified by the European Commission as a priority stream because of the large amounts that are annually generated and the high potential for reuse and recycling embodied in these materials. Arising CDW along with the available average recycling rates of CDW for Croatia and some of its neighboring countries is shown in Table 1. Indeed, a proper CDW management would lead to efficient and effective use of natural resources and would as well help mitigate the environmental impacts to the planet. For this reason, the Waste Framework Directive [1] requires Member States to take any necessary measures to achieve a minimum target of 70% (by weight) of CDW by 2020 for preparation for reuse, recycling and other material recovery, including backfilling operations using nonhazardous CDW to substitute other materials. On the other hand, energy performance of buildings is an equally important issue in the EU and worldwide. The present condition of the existing building stock in Croatia and its neighboring countries is deeply unsatisfactory. Most buildings are 'substandard' in terms of energy efficiency, comfort and health. The largest share of energy consumption in buildings in Croatia is used for space heating (56% and 52% in residential and nonresidential buildings, respectively) and more than 83 % of buildings consume from 150 to 200 kWh/m^2/a of energy for heating. In EU 27 buildings consume around 40 % of energy needs and account for 36 % of EU's CO_2 emissions.

The ECO-SANDWICH wall system, conceived and developed at the Faculty of Civil Engineering in Zagreb, seeks to tackle all of the issues outlined in the preceding paragraph. The ECO-SANDWICH wall system is an innovative prefabricated ventilated wall panel with integrated core insulation allowing very low energy design and retrofit of buildings. It consists of two precast concrete layers interconnected through stainless steel lattice girders. Around 50% of the total aggregate quantity needed for production of concrete layers has been replaced with recycled aggregate obtained from CDW. A

Country	Arising CDW [million tons]	CDW reused or recycled [%]
Bulgaria	7.80	N/A
Hungary	10.12	16
Romania	21.71	N/A
Slovenia	2.00	53
Croatia	2.34	7
Serbia	1.00	0

Table 1: Average recycling rate of CDW.

newly developed mineral wool manufactured using Ecose® Technology, which uses biobased minerals free from formaldehyde, phenol and petrochemicals, is used as a thermal insulation material. Being harmonized with both Energy Performance of Building Directive - EPBD (2002-91 EC), its Recast EPBD II (2010-31-EU) [2] and EU Waste Framework Directive (2008/98/EC), the ECO-SANDWICH wall system is expected to facilitate the implementation of both legislations by providing a market for recycled CDW and by substantially improving the energy balance of the existing as well as planned building stock.

The potential of the ECO-SANDWICH in the aforementioned sense has been recognized by the European Commission as funding for market penetration and further development of the wall system has been approved through the EU's CIP-EIP Eco-Innovation 2011 initiative. This paper will present an LCA model that has been developed with the aim of preliminary assessment of embodied energy, embodied carbon and production of by-product wastes during the life cycle of the ECO-SANDWICH panel. A comparison with a generic concrete EPS-core wall panel is also given.

2 LCA OF THE ECO-SANDWICH

2.1 Goal and scope definition

The developed LCA model aims to assess embodied energy, embodied carbon and production of by-product wastes during the life cycles of the ECO-SANDWICH panel and a generic EPS-core wall panel. In order to achieve this goal, the panels were analyzed during different stages of their life cycle, namely resource acquisition, panel manufacture, transport to the construction site and installation, maintenance and use, and, finally, demolition of the panels, recycling of components and disposal of residual wastes.

2.2 Functional unit

In order to achieve an objective comparison between the panels, a functional unit of one panel with dimensions of 6.2x2.8m was selected in a way to achieve system equivalency. Both panels enable construction of buildings with the same internal useable floor area and internal useable building volume. The assumed life span of the panels was 50 years with no maintenance necessary in that period. It was assumed that the panels will be used for construction/retrofitting of buildings located in Zagreb, Croatia with an in-building generation of heat with natural gas furnace. The system equivalency does not hold true in terms of thermal properties of the panels and the use of recycled concrete. Concrete for the ECO-SANDWICH is produced using 50% of aggregates obtained from CDW whereas it is assumed that the generic concrete EPS-core panel is manufactured using virgin aggregate only.

2.3 Life cycle inventory analysis

The scheme of the model used for assessment of environmental impacts of the ECO-SANDWICH wall panel during its life cycle is depicted in Figure 1; SimaPro software [3] was used to model the entire life cycle.

The ECO-SANDWICH consists of two precast concrete layers; recycled concrete aggregate and recycled brick aggregate is used in production of concrete for the inner and outer layer respectively (around 50% of total aggregates needed in production of concrete is obtained from recycled CDW, and the exact quantities were entered in the model). The exact quantities of cement and water used in production of concrete for the panel were also incorporated in the model. The weight of steel used for reinforcement and coupling of concrete layers amounts to around 100 kg and the total weight of Ecose® mineral wool used in one panel is around 90kg. The total weight of one ECO-SANDWICH wall panel is around 5900 kg.

The generic wall panel that was modeled consists of two precast concrete layers (with a thickness of 6 cm each) and 10cm EPS core (volume weight 30kg/m^3) as insulation. Same quantities of concrete components were used in the mix as for the ECO-SANDWICH panel, save for the fact that only virgin aggregate was used. Also, same types and amounts of steel for reinforcement and coupling of layers were assumed. The total weight of one generic wall panel amounts to around 5260 kg.

The data on energy and materials used in modeling of panel components and manufacture of panels were obtained from the partners in the ECO-SANDWICH project. However, if it was found during the compiling of LCI data that the necessary data was not sufficiently reliable or lacking, process information from SimaPro databases [4, 5] were used due to limitations of time and cost. Transportation was taken into account using appropriate maps to determine the distances between the facilities involved in the processes of resource acquisition, panel manufacture and panel recycling/disposal as well as the distance from the panel production factory to the construction site; equal assumptions were made for both panels, i.e. both panels produced at the same factory with material obtained from the same suppliers and only road transport is used. Functional unit for transport was assumed to be ton-kilometers (tkm) which is equal to transport of one ton of goods over one kilometer.

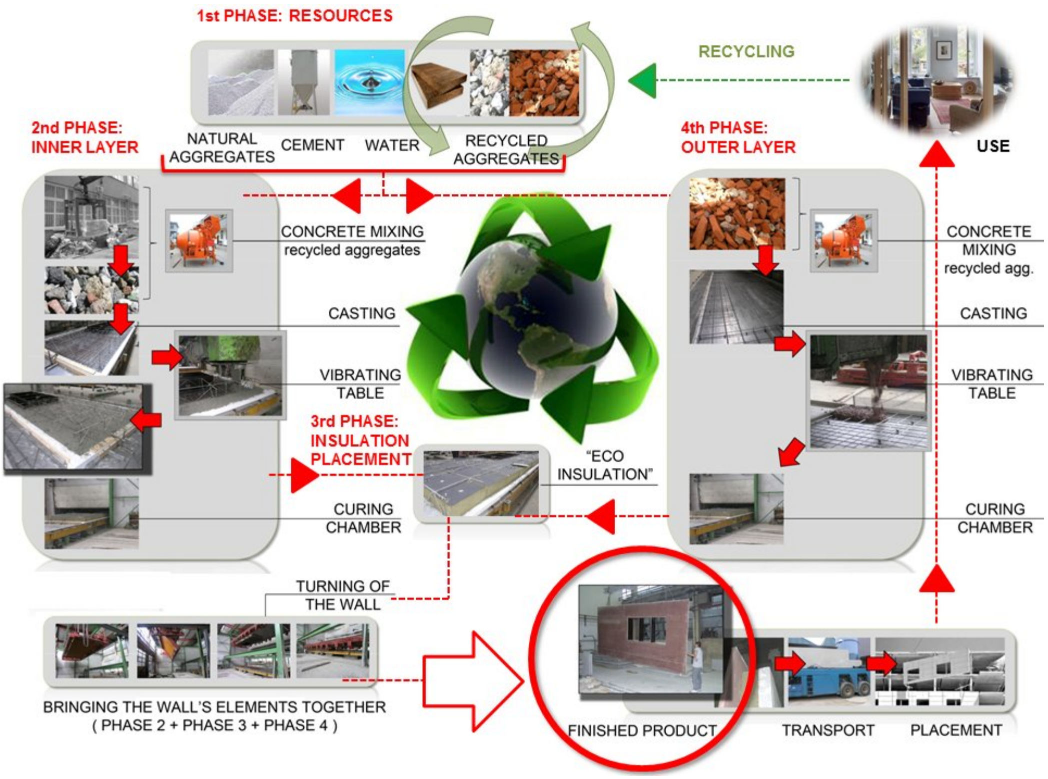


Figure 1: Life cycle model of the ECO-SANDWICH panel.

2.4 Assessment methods and impact categories

As outlined in the goals and scope definition, our aim was to assess the life cycles of the ECO-SANDWICH panel and a generic EPS-core concrete wall panel. Single issue methods were used to achieve this goal. Embodied energy was calculated using the method to calculate Cumulative Energy Demand (CED) as published by ecoinvent version 1.01 and expanded by PRé Consultants for energy resources available in SimaPro database [3]. Characterization factors for nonrenewable fossil resources impact category were used. Embodied carbon was calculated using the IPCC 2007 GWP 100a method employing climate change factors of IPCC with a time frame of 100 years.

3 RESULTS OF THE LIFE CYCLE ASSESSMENT

The results of the performed life cycle analysis for the ECO-SANDWICH and a generic EPS-core concrete wall panel can be seen in Figure 2. It can be seen that the maintenance and use phase has the largest contribution to the embodied energy and embodied carbon impact categories for both panels. The more favorable effect in the use phase of the ECO-SANDWICH stems from the possibility of achieving superb thermal performance through combination of recycled concrete, Ecose® mineral wool and a ventilated layer. As a side note, a way of achieving even better thermal performance of the ECO-SANDWICH was also conceived and will be implemented through the CIP Eco-innovation 2011 initiative.

Resource acquisition also presents s significant contribution to the overall impact of the ECO-SANDWICH as well as the generic panel. Although the ECO-SANDWICH uses significant amount of recycled aggregates, the use of Ecose® mineral wool as opposed to EPS insulation weighs more favorably for the ECO-SANDWICH (see Table 2). Observing the total impact of both panels, it can be seen that the use of the ECO-SANDWICH allows for saves of around 46% and 39% per panel in terms of embodied energy (MJ) and embodied carbon (kg CO_{2eq}), respectively.

A possibility that the use of the ECO-SANDWICH presents in terms of fostering more efficient and effective management of construction and demolition waste is also worth mentioning. As part of the ECO-SANDWICH action proposal preparation, a significant effort was made to obtain data on the types and amounts of CDW that are generated in Croatia and neighboring countries. According to the Croatian Environmental Protection Agency, 46152.05 tons of concrete CDW and 15823.56 tons of brick CDW were generated in 2009. Therefore, by applying the ECO-SANDWICH (i.e. by implementing the strategy that is described in detail in the ECO-SANDWICH action proposal [6]) around 16% of concrete CDW and 23% of brick CDW would be recycled in Croatia. Additionally, around 12272 tons of recycled brick aggregates and 6136 tons of recycled concrete aggregates would be reused in the ECO-SANDWICH wall panel systems on the planned replication market.

4 CONCLUSIONS

Large amounts of recyclable and reusable construction and demolition waste that are annually generated coupled with an exigent need to improve energy performance of the building stock in the EU and neighboring countries present an excellent opportunity for development of green solutions. The ECO-SANDWICH panel, a ventilated prefabricated wall panel that utilizes recycled CDW and mineral wool produced using innovative and sustainable Ecose® technology, tackles these priority issues in an eco-innovative format through the following: by encouraging reuse and recycling of CDW in order to shift CDW management from disposal to recycling; by reducing utilization of natural resources thus preventing landscape degradation; by promoting the substitution of conventional thermal insulation materials with mineral wool produced using innovative and sustainable technology, therefore leading to a reduced environmental impact; and, by promoting implementation of prefabricated, energy efficient products in order to enable reduction of primary energy consumption in residential and commercial buildings.

Figure 2: LCA results (values per panel).

	ECO-SANDWICH		EPS PANEL	
	MJ	kg CO_{2eq}	MJ	kg CO_{2eq}
concrete	7,130	1,354	4,720	890
insulation	1,380	131	5,106	220
steel	1,980	107	1,980	107
TOTAL	10,490	1,592	11,806	1,217

Table 2: Environmental impact of panel components.

The performed LCA analysis presented in this paper indicates the potential of the ECO-SANDWICH wall system in terms of reducing embodied energy and embodied carbon. By comparing the ECO-SANDWICH with a generic EPS-core concrete wall panel, it can be seen that the use of ECO-SANDWICH allows for significant saves - around 46% of embodied energy and around 39% of embodied carbon per panel for a life span of 50 years. However, in order to better highlight the environmental benefits of the ECO-SANDWICH wall system and indicate the possibility for further optimization, a detailed LCA study using a comprehensive impact assessment method such as the Eco-indicator 99 is necessary and will be performed as part of the EU's CIP Eco-Innovation 2011 initiative.

5 ACKNOWLEDGMENTS

We extend our sincere thanks to all our partners in the ECO-SANDWICH project: Faculty of Architecture, University of Zagreb, Croatia; Beton-Lucko Ltd., Lucko, Croatia; KNAUF Insulation Ltd., Novi Marof, Croatia; EURCO Inc., Vinkovci, Croatia. Their contributions made the realization of the project a reality. We would also like to extend our thanks to all of the institutions that recognized the potential of the ECO-SANDWICH system and provided their support. Finally, we acknowledge the support that the Ministry of Science, Education and Sports of the Republic of Croatia provides through funding of the research project 'From Nano- to Macro-Structure of Concrete', project code: 082-0822161-2990.

6 REFERENCES

[1] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, 2008, Official Journal of the European Union L312/3

[2] Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast), 2010, Official Journal of the European Union L153/13-35

[3] PréConsultants, 2008, SimaPro 7.1, Amersfoort, The Netherlands

[4] BAUWAL, 1996, BAUWAL 250, Ökoinventare für Verpackungen, Schriftenreihe Umwelt 250, Bern

[5] Frischknecht, R., Bollens, U., et al., 1996, Ökoinventare von Energiesystemen, 3rd ed, ETH-ESU 96 system proceedings

[6] Banjad Pecur, I., Milovanovic B., et al., 2011, ECO-SANDWICH: Energy efficient, recycled concrete sandwich façade panel, action proposal submitted for CIP Eco-innovation 2011 initiative

Sustainability Applied To Offshore Accommodation Modules

R.C. Fikkert[1], E. Durmisevic[1], M.E. Otheguy[2]
[1] University of Twente, Enschede, The Netherlands
[2] Keppel Offshore and Marine Technology Centre, Rotterdam, The Netherlands

Abstract
Current issues of increasing material scarcity, environmental awareness and the willingness to explore more sustainable technologies are opening the way for the offshore industry to improve the sustainability of offshore accommodation modules. The objective of this paper is to investigate if Design for Disassembly is an appropriate method to increase the sustainability of Offshore Accommodation Modules. A method is developed from literature and tested on Self-installing Platforms. The case study delivered a flexible and connectable module system for accommodations. Life Cycle Analysis will determine environmental benefits in material and energy use. Functional assessment promises added functionality in terms of flexibility in use, maintenance, upgrading and remanufacturing. First reasoning about costs suggests lower life cycle costs and lower transformation costs.

Keywords:
Sustainability, Design for Disassembly, Offshore Accommodation Modules, Life Cycle Analysis

1 INTRODUCTION

The offshore industry has a 100-year history in the oil and gas sector with notable achievements but also unavoidable associated risks and pollution of the sea and the atmosphere. Issues of energy security, environmental awareness and the willingness to explore more sustainable energy technologies are now driving industrial developments of tidal, wave and wind energy facilities. Materials are furthermore becoming scarce and more costly, enlarging the need for sensible material use. The sustainability in terms of embodied and operating energy of the offshore platforms themselves is therefore becoming an important issue.

This paper addresses an opportunity to enhance the sustainability of offshore platforms and particularly of their accommodation modules by applying concepts and techniques of Design for Disassembly (DfD).

2 DESIGN FOR DISASSEMBLY AND OFFSHORE PLATFORMS

2.1 Sustainability

The term sustainability is nowadays very popular amongst designers and architects. From the first generally accepted definition by Brundtland [1] the term has had many uses and connotations, which has given the term a plethora of meanings [2].

The way to reach sustainability is also very diverse. Representing the environmental impact in a single footprint is often used to provide a visual overview of the severity of the strain on the biosphere's capacity [3]. Methods such as the 'sustainable emissions and resource usage' method focus on limiting the use of resources and the production of emissions to an acceptable level [4]. Methods that merely try to limit use of materials and production of emissions have some limitations. The continuous extraction of finite materials can hardly be called sustainable and the restricted use of materials seems a negative way to approach the challenges that lie ahead.

Many methods agree reconciliation of natural, social and financial benefits is needed to create truly sustainable products [5, 6, 7]. One method that is widely used within all sorts of organisations is the 'Triple Bottom Line' method [6, 8] (figure 1). The 'Cradle to Cradle' method also shows that taking all three factors into account can indeed in many cases be beneficial [7].

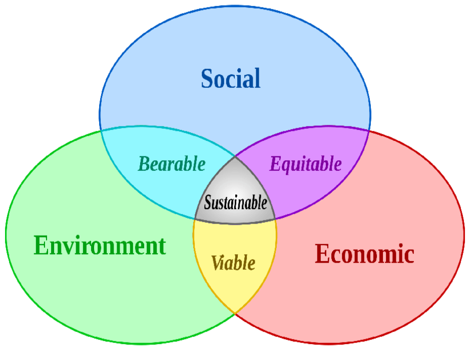


Figure 1: Visual representation of the triple bottom line [9]

Reuse of materials, components and systems is an important aspect to achieve more sustainable products and buildings [10, 11]. Reuse is furthermore one of the most preferable end-of-life scenarios [12, 13].

2.2 Disassembly benefits

Non-destructive disassembly is needed to safeguard the reuse potential of systems, components and materials. Design for Disassembly facilitates reuse and recycling at what was seen as the end of the lifecycle [14].

DfD has already been used for several decades in the automotive, consumer electronics, computer and other industries [15], but in other areas it is relatively new. In the construction sector DfD has been in focus for some decades with different results on aesthetics and acceptance [16, 17].

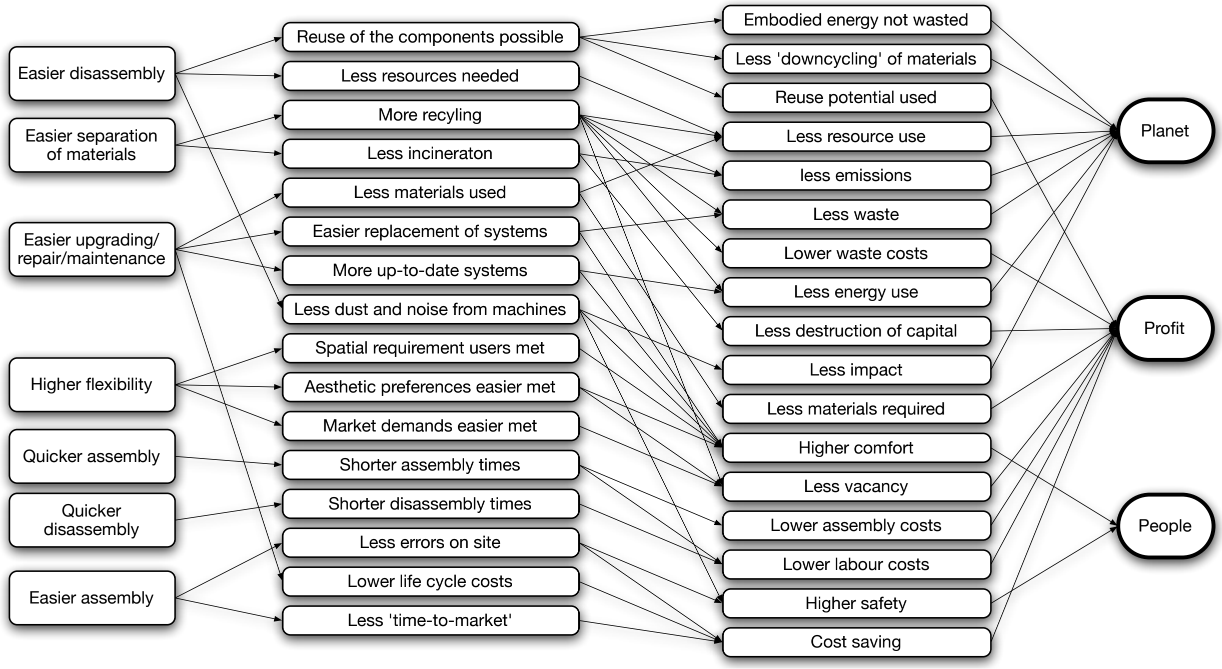


Figure 2: Connections between Design for Disassembly benefits and Triple Bottom Line [6] categories.

There are many benefits to DfD, not only for the planet, but also for people and profit. Benefits from disassembly include shorter disassembly times [16, 18], lower disassembly costs [16, 19] and less impact on the direct environment [16].

Easier disassembly in many cases also means a simplification of products [19], which has benefits for assembly times [18], assembly costs [19] and the number of on-site errors [16].

During the use phase of the products the benefits include easy upgrading [11, 20] and flexibility in spatial layouts [16].

Ease of repair and maintenance furthermore improves quality and saves costs by saving materials [16, 19]. Ease of upgrade, repair and maintenance also means that aesthetic preferences are easier to meet and that the service life of the building is extended [14, 16, 21].

Because parts, components and systems are non-destructively removed, they can be reused in the same or in other buildings [11, 14, 16, 21]. Reuse of components reduces resource use [11, 16, 22] and preserves the energy embodied in the materials [14, 16 23]. Furthermore reuse of the components reduces the amount of waste and prevents the destruction of capital [20].

Figure 2 summarises the benefits in a visual scheme to provide overview how the benefits link to the triple bottom line [6] categories.

2.3 Designing for Disassembly

The disassemblability aspects need to be taken into account from the start of the design process to optimise the results [24]. Systems, components and parts need to be independent form one another and have to be exchangeable to ensure that they do not cause unwanted effects in the disassembly process.

These criteria are therefore the main performance criteria of the transformation capacity. To reach this in the functional, technical and physical domain there are eight aspects that are important [25] (figure 3):

- Functional independence: Different functions should be independently changeable.
- Systemisation: Groups of functions have to be clustered in systems
- Hierarchy: Components and parts that are changed more often should be lower in hierarchy than more fixed ones. For example the load bearing structure should be high in the hierarchy.
- Base element specification: One element acts as an intermediary between the parts in a component and the higher order components
- Life cycle coordination: Coordination between material and functional life cycles ensures correct specification of hierarchy, assembly sequences, etc.
- Assembly sequences: Parallel assembly sequences ensure independent change of components.
- Type of connection: Dismountable connections allow for disassembly without disturbing other parts.
- Geometry: An open geometry allows for independent removal of assemblies.

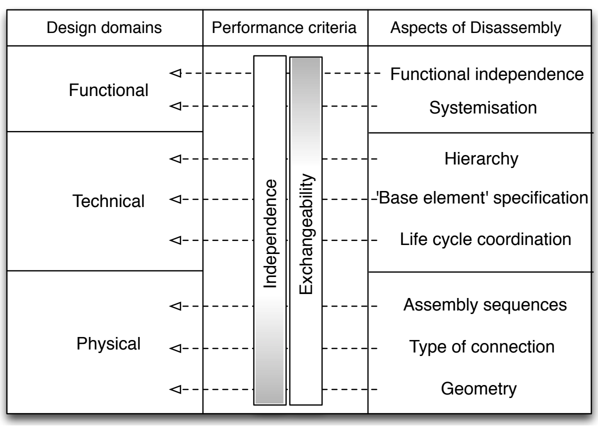


Figure 3: Relation of DfD aspects to design domains [25]

The high flexibility of assemblies and components and the high independence of systems allows for flexible uses of the structure without committing to one floor plan, one aesthetic appearance or one use scenario.

2.4 Design process

In the offshore industry many rules and regulation are in use to guard the safety of employees and environment. These extensive rules differ from one country to another and for example have different demands about layouts. Especially the accommodations of the platforms are subject of changing standards [26-31]. Current design process often takes the most stringent rules and the peak occupancy to design the accommodations.

This leads in many cases to over-dimensioning of accommodations in terms of number of cabins and size of recreation and mess room. To prevent waste of energy and materials, the accommodations need to be adjusted to changing demands over time. Therefore Design for Disassembly needs to be implemented in the design process of offshore accommodation modules.

This research about Design for Disassembly aspects led to a method that is used in the case study design and that is updated constantly according to new insights from the thorough evaluation of the iterative accommodation design.

3 ACCOMMODATIONS ON OFFSHORE PLATFORMS

3.1 Case study choice

The case study needs to take flexible requirements into account where a fixed design is currently in place. The case study choice therefore is to investigate a Self-installing Platform (SiP) (figure 4).

(a) (b)

Figure 4: (a) SiP for marginal gas field (b) Self-installing substation and accommodation platform for 80-turbine offshore wind farm.

These designs have or could have a 'table-top' design with all accommodations on top of the main deck. Different use is thus possible after its operational lifetime. Hull based design with enclosed accommodations are for example more difficult to update for a new function.

The platforms have different functions, but all have significant operating costs per day. Every day without operating thus presents major costs. Fast and flexible transformation has therefore the potential to account for large savings.

3.2 Life Cycle impacts

The current life cycle impacts are investigated with the Life Cycle Analysis method 'ReCiPe' [32]. The Life Cycle Analysis (LCA) of an offshore drilling rig focuses on the platform itself and in particular of the accommodation modules:

- The functional unit is taken as: "Provide a safe living area in an offshore environment for 100 people for 1 year".
- The use phase of the platform is only taken into account with regard of the accommodations. For example the drilling operations are therefore outside the scope of the analysis.
- The life cycle impacts of the inventory are mainly taken into account up to the second level of inventory (all materials and processes). Third level inventory (capital goods, such as the harbour or factory) was allocated to the platform where needed.
- Phases of the current life cycle are taken as; production, transport, use, maintenance and end-of-life.
- In the production phase general information about steel manufacturing is used to account for the steps leading up to the production.
- End-of-Life scenario was taken as dismantling in Asia, with reuse of the steel in Europe.
- Normalisation was used in the LCA to compare the impacts to an outside reference.
- Weighting factors are not applied to the outcomes of the LCA, but could be used in later comparisons.

The LCA reveals the impacts of the different phases and of the different parts of the platform. Highest normalised impacts are found on human toxicity, freshwater ecotoxicity, marine ecotoxicity and metal depletion (figure 5). The analysis shows that the accommodations are a relatively small part of the overall impacts, but nonetheless present a substantial impact on the environment. The major causes of the toxicity are linked to manufacturing and coating of the steel. The metal depletion is linked to the use of the steel itself.

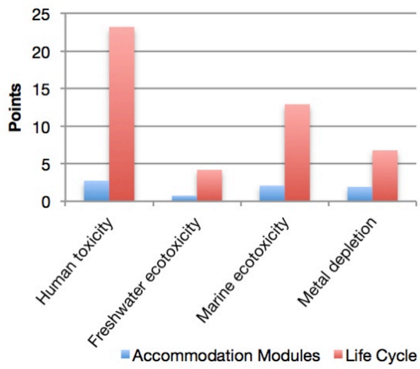


Figure 5: Four highest normalised impacts

Energy use of the platform is dominated by the heating and power usage in the use phase of the platform (figure 6). Design for disassembly could contribute to some savings in the overall energy reduction, but additional energy solutions are needed for substantial energy savings. The disposal phase and the transport of the modules are of interest, because design for disassembly could greatly reduce the energy use there. This gives directions for possible solutions for the redesign.

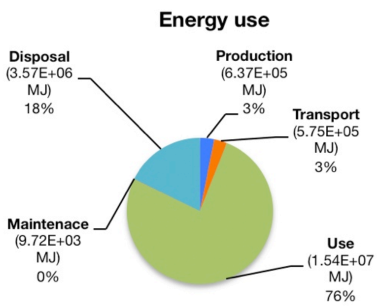


Figure 6: Energy use of the overall platform per life cycle phase

3.3 Disassembly limitations

Further analysis of the accommodations reveals problems with disassemblability of the current accommodations. Especially functional dependences, irreversible connections, sequential assembly sequences and stuck geometries are found. This provides valuable input for the redesign of the accommodations.

3.4 Design requirements

The new design of the accommodations has a large amount of requirements to generate a flexible design that can fulfil the different functional and layout changes over the lifetime. The requirements take into account;

- The applicable rules and regulations
- Safety regulations
- Inside environment
- Choice of materials
- Conditions on sites
- Spatial requirements over time
- Functional requirements of the different rooms.
- Demands per life cycle phase, including transport and commissioning

The requirements of the accommodations furthermore take the following scenarios into account:

1) Minimum oil and gas facility platform: unmanned: accommodations on host platform; 0 people [33]
2) Minimum oil and gas facility platform: manned: accommodations on Self-installing Platform; 12 people [33]
3) Offshore wind farm self-installing temporary or permanent substation/maintenance facilities for medium wind farm: maintenance of 80 wind turbines and the substation: 32 people [34]
4) Offshore wind farm self-installing temporary or permanent substation/maintenance facilities for large wind farm: maintenance of 175 wind turbines and the substation: 70 people [35]

This results in a requirements document that is used during the design phase.

3.5 Method application

The scenarios and requirements show that a flexible design is needed to meet the requirements of the accommodations. Especially upsizing the accommodations and flexible floor plans are important factors in ‘standard proofing’ the accommodation modules. Ease of transport is important for lower costs and higher flexibility of upgrading. Units that can be non-destructively removed furthermore ensure the reusability of the accommodations. Life cycle analysis shows that maximising reuse by remanufacturing and minimising transport can reduce the overall impacts. This is used as input for brainstorm sessions to generate design concepts.

3.6 Initial Design

Offshore platform often get their materials, food and other products with supply ships and some products are already transported in containers on these ships. This provided the idea to use containerised modules with standard container sizes. The standard container size could allow for cheap transport with standard container ships and for easy handling by standard cranes. Furthermore a standard 20’ container can satisfy the spatial requirements of the 9.5 - 12 m^2 per cabin that several relevant rules and regulations prescribe [26-31].

3.7 Design development

The detailed design indeed uses containerised units with standard intermodal dimensions that can be added together to form the accommodations. Shipping the containers in a standard container ship was however found to impose high structural demands that would increase the weight of the units. An external structural frame is therefore added to reduce the structural demands of the units.

The platforms and ports are often far apart, reducing the benefit of standard container ships. Because many of the benefits of standard container handling still hold true for this system, this solution provided an optimum between low weight and ease of transportation.

Using modules with the dimensions of standard 40’ containers for hallways means that 5 containerised units of 8’ wide can be used next to each other per hallway-module. In the scenarios the number of cabins was maximally 35, which means that four decks are needed. If larger accommodations are required, upsizing will be achieved by expanding sideways: using more than four accommodations decks is not custom in practice. The structural frame provides the structural strength to carry the top layers (figure 7).

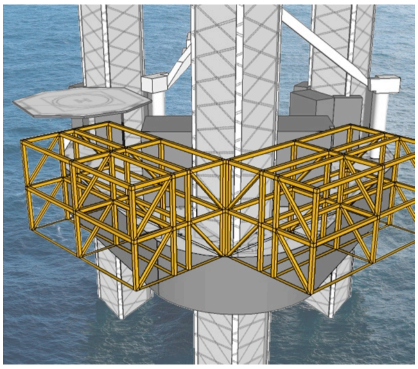


Figure 7: 3d model of the structural frame on a jack-up platform

Design features of the accommodation system are:

- Division between the decks provides extra flexibility because the top and bottom decks can be removed for maintenance or replacement separately.
- The frame can be added and removed in the width of 5 units, providing additional deck space when accommodations are removed.
- The modules can be attached to each other and the frame with twist lock connections (figure 8) that are also used in shipping containers.
- The sidewalls can be removed to combine the units into larger spaces. The functions of the units can therefore change, for example from cabins to recreation room and vice versa (figure 9).
- The connections for ventilation, lighting, water and fire detection are placed in the lowered ceiling. The connections for power, internet, television, communications and sewage are under the floor.
- The panels of the ceiling and floor can be individually removed to access the connections.
- The cables, pipes and ducts go the short side of the cabins and are connected to the hallway modules with demountable connections for fast assembly and disassembly.
- The hallway provides a ‘central street’ with the main ducts and pipes (figure 10).
- The sides of the lowered ceiling are part of the structure of the units and provide an airtight division to increase fire safety.
- The walls connected to the units have flexible seals to provide high gap-tightness and good sound insulation.

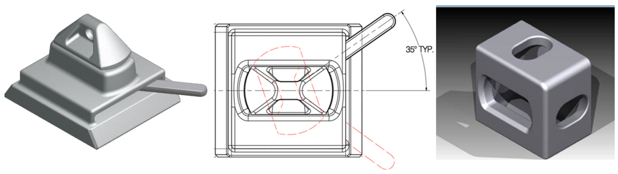


Figure 8: Twist lock connection for containers. [36]

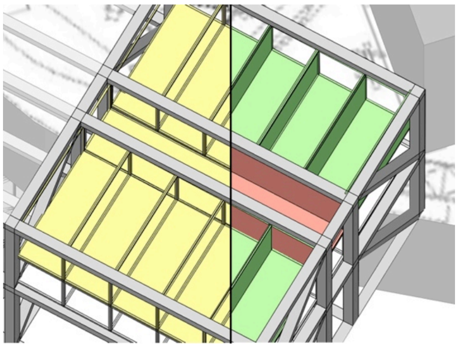


Figure 9: Two possible uses of the containerised modules: open and closed floor plan

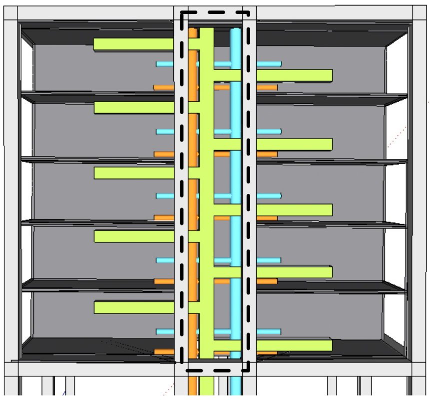


Figure 10: Connections through ‘central street’

4 LIFE CYCLE BENEFITS

4.1 Environmental impact

Life Cycle benefits in the environmental impact of the accommodations are needed to improve the sustainability of the accommodations. First indications on the differences in environmental impact are:

- The transportation of the overall platform will be reduced with the more flexible design. Therefore the impacts due to transport will be reduced as well.
- The demountable connections make the accommodation fit for remanufacturing, which will reduce waste and increase the use of the embodied energy.
- The steel frame is also demountable and therefore fit for remanufacturing and use in another platform. This minimises the need for newly manufactured steel and reduces the impacts caused by manufacturing.

Added measures such as environmentally friendly coating reduce the impacts even further.

The comparison between the current case and the redesign will be made in more detail in a Life Cycle Analysis later in the research process.

4.2 Life Cycle Costs

Rough estimates of production, transport and installation costs will be compared to the current case. Due to the high operating costs per day, the costs of adapting the units are likely to be lower than in the current costs.

Reuse of the units can furthermore provide a saving in the manufacturing costs of new accommodations and the elimination of scrapping needs provides savings in end of life transport costs. The costs of industrially producing the standardised modules is likely to cost the same or less. Overall life cycle costs of the redesign are therefore assumed to be lower. A network of remanufacturers might be needed to ensure this reuse of parts, components and systems.

4.3 Life Cycle Functionality

The functionality of the accommodations increases in the redesign. Benefits include easier maintenance, higher flexibility and easier upgrading. The higher flexibility in spatial layout and possibility to remove parts of the structural frame and accommodations furthermore allows for a more versatile use of the platform.

5 SUMMARY

This paper describes the benefits of Design for Disassembly applied to the accommodations on board offshore platforms. It is shown that there are many advantages and that offshore platform can benefit from the use of Design for Disassembly. The research resulted in a method that is applied in accommodation design. The results are shown and the coming research steps are explained. Finally the potential benefits are mentioned.

6 REFERENCES

[1] World Commission on Environment and Development (1987). From One Earth to One World.

[2] Marshall, & Toffel. (2005). Framing the Elusive Concept of Sustainability - A Sustainability Hierarchy.

[3] Wackernagel, & Yount. (2000). Footprints for Sustainability: the Next Steps.

[4] Graedel, & Klee. (2002). Getting Serious About Sustainability.

[5] Natural Step (2012). Natural Step method. Retrieved 15th April 2012, from http://www.naturalstep.org/

[6] Elkington, J. (1998). Cannibals with Forks: The Triple bottom line of 21st Century Business. Gabriola Island: New Society Publishers.

[7] McDonough, W., & Braungart, M. (2002). Cradle to Cradle; Remaking the way we make things: North Point Press.

[8] Norman, & MacDonald. (2003). Getting to the Bottom of “Triple Bottom Line”.

[9] The IUCN Renowned Thinkers Meeting (2006). The Future of Sustainability: Re-thinking Environment and Development in the Twenty-first Century.

[10] Crowther, P. (2005). Design for Disassembly - Themes and Principles (pp. 9). RAIA/BDP Environment Design Guide.

[11] Fletcher, S. L. (2001). Developing Disassembly Strategies for Buildings to reduce the Lifetime Environmental Impacts by Applying a Systems Approach. University of Sheffield, Sheffield.

[12] Lansink, A. (1979). Lansink's Ladder.

[13] Hobbs, G. (1996). Management of construction and demolition wastes. BRE. BREIP, 1(96).

[14] Crowther, P. (1999). Designing For Disassembly To Extend Service Life And Increase Sustainability.

[15] Rosenberg, D. (1992). Designing for Disassembly. Technology Review, 95(November/December), 17-18.

[16] Guy, & Ciarimboli. (2005). DfD: Design for Disassembly in the built environment.

[17] Kronenburg, R. (2007). Flexible; Architecture that responds to change. London: Laurence King Publishing Ltd.

[18] Harjula, T., Rapoza, B., Knight, W. A., & Boothroyd, G. (1996). Design for Disassembly and the Environment. CIRP Annals - Manufacturing Technology, 45(1), 109-114.

[19] Boothroyd, & Alting. (1992). Design for Assembly and Disassembly. CIRP Annals - Manufacturing Technology, 41(2), 625-636.

[20] Geraedts. (1999). Design for Change, Flexcos vergelijkt kosten en baten van flexibiliteit: Delft Technical University.

[21] Bloemen. (2010). Design for Disassembly of Facades. Delft University of Technology, Delft.

[22] Westkämper, Alting, & Arndt. (2000). Life Cycle Management and Assessment: Approaches and Visions Towards Sustainable Manufacturing (keynote paper). CIRP Annals - Manufacturing Technology, 49(2), 501-526.

[23] Dimoudi, A., & Tompa, C. (2008). Energy and environmental indicators related to construction of office buildings. Resources, Conservation and Recycling, 53(1-2), 86-95.

[24] Villalba, G., Segarra, M., Chimenos, J. M., & Espiell, F. (2004). Using the recyclability index of materials as a tool for design for disassembly. Ecological Economics, 50(3-4), 195-200.

[25] Durmisevic, E. (2006). Transformable Building Structures. Delft, Delft University of Technology.

[26] The Danish Energy Authority (1992). DEA Executive Order No. 579 of 23 June 1992. Copenhagen: Danish Ministry for Environment and Energy.

[27] UK Health and Safety Executive (1996). Guidance for Inspectors on Offshore Installations and Wells. London.

[28] Standards Norway (2004). NORSOK S-002: Working Environment. Lysaker.

[29] Standards Norway (2006). NORSOK C-001: Living Quarters Area. Lysaker.

[30] International Labour Organisation (1949). C92 Accommodation of Crews Convention (Revised). Paper presented at the General Conference of the International Labour Organisation, Geneva.

[31] International Labour Organisation (1970). C133 Accommodation of Crews (Supplementary Provisions) Convention. Paper presented at the The General Conference of the International Labour Organisation, Geneva.

[32] Goedkoop, M., Heijungs, R., Huijbregts, M., Schryver, A. D., Struijs, J., & Zelm, R. v. (2009). ReCiPe 2008. A life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level.

[33] Perenco UK (2012). Trent and Tyne. Retrieved 14th August 2012, from http://www.perenco.com/operations/united-kingdom/trent-and-tyne.html

[34] Keppel Verolme BV (2010). Global Tech 1. Retrieved 14th August 2012, from http://www.keppelverolme.nl/global-tech/

[35] London Array Limited (2012). Harnessing the power of offshore wind. Retrieved 14th August 2012, from http://www.londonarray.com/

[36] Krisry International, Inc (2012). Intermodal products for the transport industry Retrieved 15th August 2012, from http://www.krisryinc.com/

Towards a Long-term Stakeholder Approach

H. Boomsma[1], J.J.N. Lichtenberg[2]

[1]Inno-Experts, Eindhoven, The Netherlands.

[2]Department of the Built Environment, Eindhoven University of Technology, Eindhoven, The Netherlands

Abstract

This paper is about an approach to get a better understanding of especially the so-called long-term stakeholders (e.g. tenant and owner), in order to be able to design buildings that optimally serve the long-term stakeholders and to generate fundamental sustainable solutions. The approach is now applied and evaluated in projects. This paper is to present and establish the approach, to report some first experiences in case projects and to draw some preliminary conclusions regarding the method, its results, the obstacles especially regarding the process and future research topics

Keywords:

Long-term stakeholder, User, Exploitation, Value, Slimbouwen

1 INTRODUCTION

The aim of this paper is to present and to establish an approach to achieve sustainable buildings primary based on supporting the interest of long-term stakeholders. It is also the aim to open discussion about specific matters concerning this approach and its translation into a procedure or methodology. The instrument is already conceived into a procedure and the first practical experiences are available. Based on these first experiences some basic research questions will be discussed. All and all providing answers but also new questions. However the paper is also aiming to indicate research areas. In that sense this paper is a presentation of a research area build around a new approach indicating the potentials rather than already extensively researched and proven results.

2 SUSTAINABILITY

While striving for sustainability in the building industry it is generally accepted that buildings are assessed according to methods representing sustainability characteristics. However in general the means seam to have become a target as such. Buyers are asking for and developers and suppliers display with high ratings in BREEAM and other assessment tools. For the time being the market seems to accept that.

However in an increasing number of cases the tension between a high score in any of the available assessment systems and 'real' sustainability is obvious.

Regarding the fact that the assessment instruments are hardly comparable by measuring different aspects of the environmental impact, according to different approaches and methods and using different databases, the question is whether these methods do provide a realistic valuation to characterize the impact of a building in its environment or on its value, both fundamental sustainability aspects. It is for example clear that the amount of materials used in a building is related to the footprint, whilst some assessment instruments do value the material choice but not the amount used. Volume reduction is also related to sustainability, but in some cases it can be wise to invest in oversized space in order to be flexible in the future. Also flexibility is still a slippery area. It is clear that a flexible building will contribute to prolong the life span, which is, beyond any doubt, an act of sustainability. However, in many assessment systems flexibility is even not involved and if so, it appears not to be mature in a sense that it is easy to abuse the tools with a set of measures for a favourable outcome without improving the real flexibility nor sustainability. Many companies already explore these possibilities for the benefit of their success. In case of abusing or misrepresentation this is called greenwashing.

Although these instruments do have beyond any doubt an important function in the awareness and adoption of sustainability in society, the question arises whether in the long run these instruments can maintain their credibility as a reliable indicator for sustainability.

Starting point for this paper is the assumption that sustainability is strongly related to the purport of value.

3 VALUE

The most cited and still generally accepted definition of sustainable development is the so-called Brundtland definition (Brundtland, 1987) [1]:

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

Related to buildings, to be considered as a development or part of a development (on district level), the definition can be interpreted as buildings that meet present needs but regarding sustainability, above all, future needs. This approach forces us to rethink the value of buildings regarding its operation in terms of energy, maintenance, adaptability and in case of end of life, also the demountability, reusability and recyclability. Furthermore the way buildings can contribute to for example a higher users efficiency, which is hardly validated in the present sustainability assessment instruments. To conclude one could argue that todays sustainability approach is almost exclusively focussing on building related characteristics, while for sustainability one should rethink the deeper meaning of value.

In economic terms value is based on the ability to serve human wants. Value in itself is thus subjective, because it depends on the perception of humans of how well they are served and it depends on their needs, which can change over time. Both the dependency of perception and the change over time make the conception of ‘value’ very difficult to capture.

Apparently there is no such thing as the objective value of a building, we can only determine the value of a building in terms of the way it fulfils the needs of its users over time. For this we should pay attention to those users.

In this case we define users of a building or a built environment as anyone that have interaction with it during its period of use.

Hereafter these users are called ‘long-term stakeholders’, because they are the ones to determine the value of a building or a built environment during its lifespan, thus according to Brundtland’s definition also determining its sustainability.

4 A LONG-TERM STAKEHOLDERS APPROACH

Practically the above means that for example not the interests and drives of a conventional project developer or the contractor is leading but the interest of long-term stakeholders like occupants and owners of the building and also the users and owners of its environment like the municipality and neighbour tenants and owners.

Therefor a sustainable approach for developing real estate by giving central stage to the interests of these users, the long-term stakeholders, is proposed. It should be noted that they have no primary interests in the development of real estate but they have fundamental interest in using the real estate for their own processes that can range from ‘living’ to using it for production purposes.

Especially being aware of the fact that in an average break down of a users organization, whether it is a consultancy office or a construction company, the building related costs will be low, compared to those related to the primary process, mainly costs of operations of its users, it is easy to understand that real estate that supports the primary process in a better way, represent substantially more value for its users.

Presuming that it is valuable to develop real estate based on the interests of long-term stakeholders, the following questions arise:

- How should a ‘long-term stakeholder approach’ look like?
- What additional value for its long-term stakeholders will be created by this approach?
- Does such approach lead to other choices, decisions and other outcomes regarding real estate and buildings?
- What are obstacles to overcome by this approach?
- To what extend we can consider such approach as sustainable?

According to the ‘grounded theory’ [2] we will start with a proposition for this approach and to practice it in case studies. The combination of practice and science offers a field laboratory for the scientific world whilst for the projects and stakeholders involved, new knowledge regarding economy and technology will be available for strategic decisions and the design and development of new projects including the refurbishment or transformation of existing real estate. The ‘grounded theory’ provides an inductive methodology to generate know how over the projects and will be used in this research for analysing the remaining questions.

We already concluded that real estate should facilitate the processes of its long-term stakeholders in the best possible way. The expectation is that the value added by that approach is far more important than the building related operational costs.

In the conventional building industry one is focussing on the lowest price to build a building according to a set of requirements. In some cases one is prepared to take into account also hard lifetime related savings like regarding energy and maintenance. It is however not usual to develop real estate based on users values, like reducing absenteeism based on a better indoor climate, increasing labour output, or increasing the capability of adapting to reorganizations

According to Maslow’s four stages of competence (Maslow, 1943) [3], most of the initiators are to be considered as ‘unconscious incompetent’. One is not aware of the deficit and limitations of the todays approach and will not recognize the possible impact of innovation and the need to change. Parties like architects, consultants, builders and suppliers tend even to disclaim that they would not serve users properly.

The conviction is that research and demonstrations may contribute well to a better understanding and therefor to make the market ‘conscious incompetent’ being a driver for change in becoming competent.

In other words it is not to exclude that one should invest on building level in order to serve a users process that in terms of lifetime costs strongly competes and in terms of sustainability substantially reduces the lifetime footprint compared to the conventional approach.

Long-term stakeholders are focussed on their business processes, and not specifically on buildings as we noted before. So according to this premise, an approach was developed.

The approach, a co production by Inno-Experts B.V. and the chair Product Development of the Eindhoven University of Technology, Department of the Built Environment, basically can be deduced to the next six steps:

1. Identifying and involving the long-term stakeholders.
2. Inventory and analysis of processes and (immaterial) values for each of the stakeholders.
3. Selection of high impact needs in relation to the processes and possible immaterial values.
4. Translation in concrete actions or requirements that improve processes.
5. Implementation: creating design and technological solutions.
6. Evaluation of the process and impact.

5 CASESTUDIES

So far the approach is formalized and is being applied in practice in some projects, some of them already finished, most of them still under construction.

The projects to be analysed are among others:

5.1 Amsterdam Central Station

A shopping centre arcade in the renovation and extension of Amsterdam Central Station. To be elaborated hereafter in paragraph 6.

5.2 Dutch Ministry of Defence

The Dutch Ministry of Defence has a very dynamic organisation and has to reorganize and reallocate services throughout the country and abroad frequently. Sometimes services will be fused others will be split. However in all cases buildings will be needed and the challenge is to build them in a way that they are more sustainable, while at the same time have lower life cycle costs. Process information was generated about change frequencies enabling to calculate the economic consequences during the life cycle. By making buildings adaptable according to possible scenarios or some of them even movable a substantial economic advantage can be achieved. The advantages can be calculated by the implementation of life cycle modelling.

5.3 Venco Campus.

The Venco Campus is a large new building (30,000 m^2) for production, logistics and offices (approx. 8,000 m^2). The Venco Group is worldwide market leader in systems for the poultry industry. The delivery of the building will be in September 2012. An analysis of especially the office process (sales) opened the idea to invite customers to the company instead of participating in exhibitions all over the world.

This way the sales process will be more efficient and effective (this is accurately determined in this project) and the company does not need to show their innovations to competitors. The turnaround required a change in the set up of the building as a whole regarding the experience and adaptability, especially creating a visitors area and possibilities for new work concepts.

5.4 Other Projects

Apart from these examples there are also projects in housing (among others, the HoTT-project (House of Tomorrow Today [4] [5]) and on district level an existing industrial zone in Deurne. In the latter case the municipality is supported by the Province, the BOM (the Brabant development agency) searching for possibilities to revitalize the area but is not able to carry the financial burden alone. The analyses showed that a rearrangement of the area in many cases is also beneficial for companies, for example for they are, caused by expansion, spread over the area and they have interest in exchange parcels and thus create more efficient industrial locations.

All the cases discussed in paragraph 5.1 to 5.4 are still under construction and can only be fully evaluated after a period of utility. The case to elaborate is the Amsterdam Central Station Case. This project is also under construction, but the commissioner already decided to apply the new approach and to extend it also to other railway stations in the Netherlands, which now are under development.

6 AMSTERDAM CENTRAL STATION CASE STUDY

The Amsterdam Railway station is an historic place. The main building, designed by architect Pierre Cuijpers, was finished in 1889. Due to changes in mobility and transportation the building has been extended and adapted many times.

Right now the building is under construction for a major operation to be finished not earlier than 2017. The historical main building will be maintained, but the project, as a whole, will undergo major changes. The transformation includes among others cross tunnels for the High Speed Train, pedestrians and bicycles, shopping areas, the connections with metro, busses, trams, etc. In the future approx. 300,000 people will transfer each day.

Figure 1: Amsterdam Central Station, main building.

In this project the involvement is regarding the shopping area under the railway station. It is recognized that in the traditional approach as a consequence change is rather problematic. For example a change of shop, especially in case services have to be adapted, will generate a lot of work and nuisance for other shops and travellers. In some cases the main services in the ceiling or floor of the passage have to be adapted and this will not only cause nuisance, but also loss in revenues for the operational shops. The awareness of this phenomenon basically already existed, but it was never leading in making the design, simply because the economic information to deviate from the traditional approach does not exist for the stakeholders involved.

Fortunately statistical data of consumers buying behaviour and revenues in normal circumstances and during disturbance from construction operations were available. Based on these data it could be calculated what extra investment could be made to create a situation in which ease of changing shop formulas is maximised and nuisance for customers is minimised. A mutation should be established in a fraction of the usual time to rearrange.

One complicated factor is that the investments are to be done by one stakeholder while benefits will be mainly in favour of other stakeholders (shops), which were partially operated by other NS-organizations.

In a financial model it could be calculated that the investment in a flexible concept paid off for all stakeholders. Interesting is as a matter of fact, that the change in thinking had to be driven by economic reasons, but as soon as the idea was adopted it appeared that a flexible concept was not more costly than a traditional one. This can be explained by a more efficient process and higher revenues for the shops, due to shorter closing periods. Also a flexible concept created more benefits, in terms of process, efficiency and customer satisfaction, like the allocation of shops to certain sites that can be postponed which is an important quality since it is not realistic that during the construction phase all the tenants are known. According to the approach as presented in paragraph 4, the steps are described:

1. The project started with a decision to identify and add long-term stakeholders to the project team. In this case users, retail operators and maintenance and financial exploitation departments.
2. Inventory of their process and survey on the stakeholders values led to full focus on extra aspects in the project, items to optimize processes were identified as for instance; adaptability to changing customer needs, durable retail exploitability, and durable maintainability.

3. The stakeholders added relevant extra know-how and data of consumers buying behaviour in normal circumstances and during disturbance from construction operations. Bottlenecks were investigated like high refurbishing costs, commercial retail limitations due to building design, etc.
4. Based on these data, financial and economic calculations could be made and evaluated to find out what extra investment could be made to find an optimum in which on one hand the interests of all stakeholders could be served best and on the other an optimal exploitation result could be realised. This was carried out based on scenarios. The optimal scenario was called 'plug and play'.
5. From this point (this is where we are for the time being) technical solutions will be searched and compared in order to establish the required system flexibility. This leads to specific plug-and-play solutions. For example oversized air ducts, electrical installations and extra provisions ensure that refurbishment of a shop can be done without causing nuisance in the public area. Here we come close to the Slimbouwen vision to be elaborated in the next paragraph.
6. The last step regarding evaluation of the impact can only be carried out in the future as soon as the shopping area is in use.

7 EVALUATION OF APPLYING THE LONG-TERM STAKEHOLDER APPROACH

Referring to the questions as stated in paragraph 4 it is possible to evaluate the experiences so far. The first question, regarding how to implement a long-term stakeholders approach, was already discussed in paragraph 4. The other questions can be discussed following the practical experiences in the projects as described in paragraph 5.

In all cases, it appears that a focus on the process is crucial to involve long-term stakeholders in projects.

The integral participation in project teams of long-term stakeholders, like users, maintenance and retail in the developing phase was mostly new and led to enthusiasm by project partners.

What additional value for its long-term stakeholders will be created by this approach?

The experience is that new long-term stakeholders, not normally involved in development projects, bring in major information about processes and bottlenecks that would otherwise not be available for the project team.

This internal information is crucial in finding solutions that facilitate the involved long-term stakeholders in a better way. This has led to building solutions with distinctive advantages in the exploitation for long-term stakeholders. In all case-studies exploitation and life cycle economy calculations have been made. These show that the process focus leads to results with economic advantages.

A remarkable conclusion is that it could be determined that the costs directly related to the building did not exceed 10% of the added value of the organization and in all cases it appeared to be possible to develop a set of measures to improve the core process and by that realizing an efficiency improvement.

That's why this approach later was named 90-10 (Ninety-Ten). Generally not more than about 10% of the annual and life-time costs are directly related to the finance and operation of the building, while the building can create substantial value by facilitating the user organization (the other 90% of the annual or lifetime costs) in such way that the user will achieve a higher efficiency or better result.

Does such approach lead to other choices, decisions and other outcomes regarding real estate and buildings?

It turns out that focussing on the process of long-term stakeholders leads to specific solutions.

Not all case studies have reached this stage yet, but those who did like the Amsterdam Central station, Venco Campus and the Dutch Ministry of Defence have all led to significant changes in the concept of buildings involved.

As an unexpected outcome in projects, the possibility to make choices during the building process or in other words to postpone certain decisions mostly regarding services and infill/finishing, was experienced as an important stakeholders advantage.

What are obstacles to overcome by this approach?

A profound impact evaluation can only be established as soon as projects are in use. However regarding the process to establish change, a lot can be noticed already.

In most of the processes the demand for change is driven by a 'need to do' incentive or a key player motivated by a vision on possible benefits. At the same time the process is in all cases obstructed by other players in the process. Sometimes simply because their routines are disturbed, sometimes because people may feel threatened by specific changes, among others regarding their future position. Especially, the traditional developers used to work on basis of a target budget and not prepared to allow exceeding the budget for the benefit of future profits, are a good example of such obstructive phenomenon. In the current market the position of the developer is already subject of discussion, but also in an organization a division of responsibilities into different departments, will already generate an obstructive situation.

It is thanks to hard calculations and a determined personality of a so-called 'champion' [1]. The struggle against internal obstructions demands for a determined attitude in order to be able to counterbalance the natural forces against the innovation and being able to convince and persuade people based on facts and figures.

Also the collection of data requires a certain approach and to develop a way of listening to hidden information.

So far also complicated appeared to be where more than one stakeholder had to be convinced. For most of the case studies this practically means that maybe a larger impact could have been achieved but in general for projects it might be necessary to combine already at least two stakeholders to be able to show a feasible case. Challenging is to develop approaches to overcome this difficulty.

A challenge for further research is to develop a tool in order to be able to interview stakeholders and to bring up the information and demands that is even not formalized by the demanders themselves.

[1] A 'champion' after Rogers [6], is a charismatic advocate with a considerable influence in the organization and a strong believe in the success of an innovation.

To what extend we can consider such approach as sustainable?

This last research question cannot be answered yet. Apart from the fact that a certain period of use is necessary in order to get a clear picture of sustainability based on value, it is also a fundamental problem to assess a methodology designed to generate sustainable solutions, with instruments wherefore it is supposed to be a better substitute. This has to be elaborated in a later stage.

8 SLIMBOUWEN

'Slim' in Dutch means both smart and lean, 'bouwen' means 'to build'. It is a vision developed ever since 2003 [7] [8] [9]. Actually the vision induced the long-term stakeholder approach as a pre phase before applying Slimbouwen in the design and building process. Slimbouwen is so to say offering certain qualities that are meeting requirements generated by the long-term stakeholder approach.

Slimbouwen fits into the 5th stage (as a vision also into the 4th stage) of the long-term stakeholders approach. It is already elaborated in other publication, some of them mentioned here above. In this paragraph the core of the vision is elucidated.

Slimbouwen starts from the appointment that the conventional way of building does not fit the today's requirements anymore. Building does substantially affect the environment in many ways and the building process became quite complex and inefficient. In the last century step-by-step services were added to the already known building structure without re-evaluating the building tradition. Slimbouwen is based on a skeleton structure and the separation of services from the building structure. A crucial development for this approach is the use of double shell structures such as floor and wall systems that enables the installers to mount their prepared and prefabricated services as a whole and the user to change the installations during the use of the building. In double shell structures a substantial reduction of material (weight) is obtained, without losing perceived quality such as regarding acoustical insulation or vibrations.

The separation of services facilitates a simplification of the process and a substantial gain of time. Slimbouwen is a new approach for construction and a source for research in the frame of the chair 'product development' at the Eindhoven University of Technology. As a spin-off of this research also concrete product development and over 50 building projects, up to now almost exclusively in the Netherlands, are already established.

One of the main objectives is to rearrange the building process from an on-site parallel process into a sequential process existing of only a few main steps with a minimum of interdependency.

This needs to be explained. The conventional building process and especially the finishing process, can be characterized as complex in which the participants do carry out activities with a high rate of interdependency to other participants. The result is a lot of overlap, inefficiency, deficiency costs, complex coordination, lack of mutual respect, etc. Participants do have to show up on site several times since the proceeding is dependant of the progress of other participants. In fact this process is a complex process, where facades, roof, services and infill more or less are shaped in parallel.

A sequential process containing a limited number of major sub activities can only be obtained by a separation of services from the process (figure 2). In the conventional process the services are interwoven with almost all building parts and in a new approach this has to be avoided. Only then it will be possible to divide the building process into a limited number of sub processes with a low interdependency rate and therefore these sub processes can be prepared and prefabricated independently and carried out sequentially.

Each main participant is responsible for preparation, production, mounting, guaranties, etc. for the total sub system. This is similar to other industrial branches. For example in the car-industry, the electric wiring is installed in only one operation. This is facilitated by the design and engineering where the process of wiring already has been taken into account. The installation in one operation also enables the development of a cable-tree. Actually this is basically where an industrial process is all about. At first a proper division into sub processes and next comes the prefabrication and then the automation.

The sub processes are shown in figure 2.

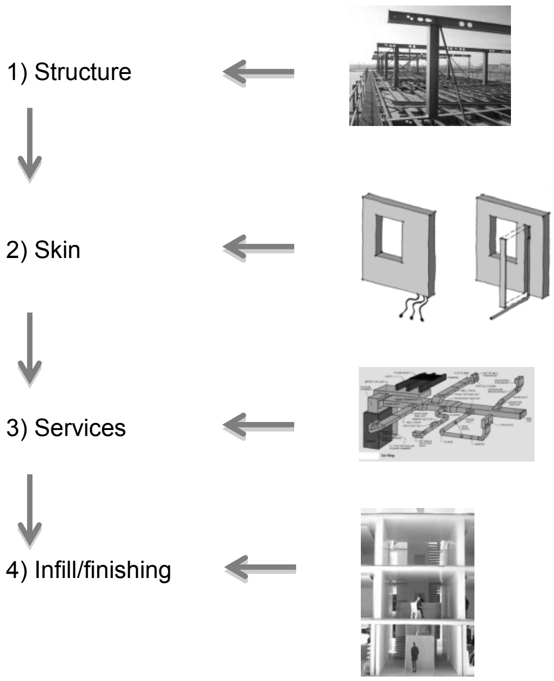


Figure 2: The Slimbouwen sequential building process.

On site the process is sequentially and disintegrated, during prefabrication the processes are still disintegrated but in parallel. In the engineering phase the process is also carried out in parallel but integrated. At this stage the core suppliers for structure, skin, services and infill contribute actively in the designing and engineering process (figure 3). This may actively be supported by a communicative ICT or BIM (Building Information Model) environment.

The importance of Slimbouwen in the frame of the long-term stakeholder (90-10) approach is threefold.

Firstly: By the process efficiency the Slimbouwen approach leads to cost reduction. In many of the projects limited by some 5 – 10 % compared to a conventional approach, but especially in the Venco Campus, where Slimbouwen was incorporated from the very first start, the reduction seems to increase up to even 30%.

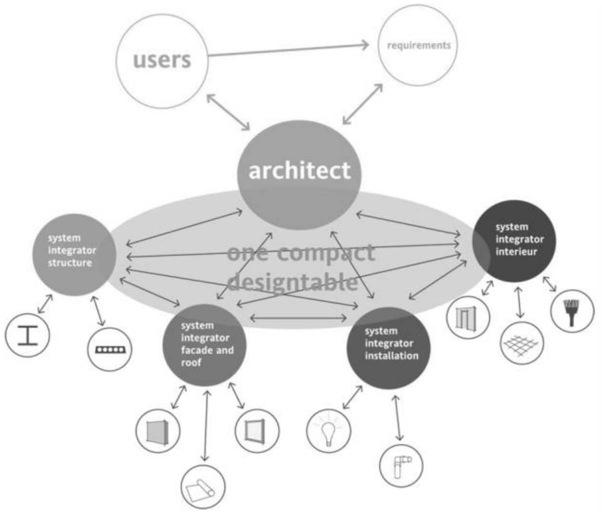


Figure 3: The Slimbouwen Engineering Model, with the architect, master builder in the middle of the representatives of the four phases participating in the design process.

Secondly: By the skeleton structure and in order to support the process, the need for accessibility of services in double shell structures, an important precondition for flexibility is implicitly established. Especially users that are prepared to calculate the real value of flexibility will easily adopt this technology.

Thirdly: By the choice of double shell structures a substantial weight reduction of approximately 50% is obtained which is an important issue regarding sustainability.

9 CONCLUDING STATEMENTS AND SUBJECTS FOR RESEARCH

In this paper the long-term stakeholders approach is established and presented. Core characteristic is that it focuses on creating value for long-term stakeholders, like tenants and owners, by carefully analysing their interests and processes as they are today, but more in particular how they will or may develop in the future. Here the method that is based on immaterial and economic values, matches the Brundtland definition for sustainable development in which '*the future generations and their abilities to meet their own needs',* is key.

The approach has already being practiced. In this paper some projects are reported, among others the Amsterdam Central Station shopping arcade. However a final evaluation based on the 'grounded theory' will be carried out as soon as the projects are in use. During the process it already became clear that some special skills are needed in order to conduct this kind of projects. To summarize in this stage:

- Business, economic and financial expertise in order to be able to carry out reliable and convincing analyses.
- Building Technology and product development skills (e.g. Slimbouwen) in order to be able to translate the new requirements into feasible innovative solutions.
- Personal skills like seniority in communication and understanding of organizations and incentives of individual stakeholders in order to make it happen and not to loose the project on false grounds.
- Furthermore as a pre condition it is important to have according to Maslow's four stages of competence at least a 'conscious incompetent' commissioning stakeholder.

However the approach is already operational, still a lot of items have to be elaborated and researched. Among others:

- Analysis of projects according to the Grounded Theory methodology in order to find similarities, systems, rules, regularity, etc. on several aspects.
- The distinction of performance indicators.
- The recognition of hidden information. Among others the possible resistance in the organization system (e.g. conflicts of interest).
- The formalisation of the approach, the development of interview tools bringing above also the non-explicit requirements, the set up of a manual.
- The development of change accelerators in order to make the market from unconscious incompetent to conscious incompetent.
- To generate data in order to be able to quantify exploitation advantages regarding efficiency, flexibility, lifetime costs, creation of value, appraising of real estate, etc.

10 REFERENCES

[1] Brundtland, G. H., 1987, Our common future*,* Report of the World Commission on Environment and Development, Published as Annex to General Assembly document A/42/427.

[2] www.groundedtheory.com, retrieved August 12, 2012

[3] Maslow, A.H.,1943, A Theory of Human Motivation, Psychological Review, 50/4: 370-96.

[4] www.activehouse.info, retrieved February 2, 2012

[5] www.actiefbouwen.eu, retrieved February 2, 2012

[6] Rogers, E. M., 2003, Diffusion of innovations, 5th edition, Free Press, New York, NY.

[7] www.slimbouwen.nl, retrieved February 2, 2012

[8] Lichtenberg J.J.N., 2004, Slimbouwen, Een herbezinning op bouwen, Een strategie voor productontwikkeling*,* Inaugural speech published by Eindhoven University of Technology, Eindhoven.

[9] Lichtenberg, J.J.N., 2005, Slimbouwen*,* Aeneas Boxtel.

A Framework to Rebuild Dynamically Specified to the Belgian Building Context

M. Vandenbroucke[1], W. Debacker[2], N. De Temmerman[1]
[1]Department of Architecture (ARCH), Faculty of Engineering, Vrije Universiteit Brussel, Brussels, Belgium
[2]Research Unit: Transition Energy and Environment (TEM), VITO, Mol, Belgium

Abstract
The last few decades design strategies and approaches have been developed to allow building transformations more easily by implementing time in design.
Those strategies and approaches have already been applied in several projects, nevertheless dynamic rebuilding is still restricted to a small scale and specific functions, such as temporary / transitional buildings. In this paper selected case studies are analysed in order to understand the difficulties of applying time-based architecture. These observations served as a basis of the development of a framework to implement dynamic building on large scale within the Belgian building context.

Keywords:
Conservation of resources, adaptability, reuse of building components, case studies, framework

1 INTRODUCTION

Nowadays a building is often designed to comply with a packet of requirements for that moment. It is designed static while living in and around a building is constantly changing. Fashion trends change, family compositions change, etc. Those changes affect the needs of the dwellers, but a building cannot respond efficiently to those changing needs. Labour-intensive construction works are necessary, because disassembly is not planned. Due to inadequate design many building materials and components are lost whenever a building no longer meets contemporary needs. Because of the way building components are connected, it is often not possible to reuse them; the components are contaminated or broken after use and new resources are needed. All this makes that the building industry in 2008 was responsible for 33% of the total waste in the European Union; this is 859 million tonnes construction and demolition waste. [1]

However, by implementing the time dimension in design, a building could be (re)build dynamically and could respond to changing requirements of society and individuals, such as changing family composition, changing patterns of life and changing work environment.
Those ideas are not new. The last century concepts, design strategies and approaches have been developed to industrialise the building process and to allow building transformations more easily. Nevertheless the implementation of those ideas is in Belgium still restricted to a small scale and specific functions, such as temporary buildings. Therefore, a framework is proposed in this paper to bring dynamical buildings more to reality. The framework responds to difficulties of implementing time-based architecture raised by an analysis of several well-known case studies. All this is preceded by a summary of some time-based design strategies and approaches.

2 (RE)BUILD DYNAMICALLY

2.1 Introduction

In the 20th century, various time-based design strategies and approaches were developed and building systems were introduced. In the following paragraphs some of those concepts are explained.

2.2 Time-based design strategies

In order to reduce construction waste to a minimum, the life cycles on material, component and building level need to be closed. To do so, Dorsthorst and Kowalczyk 2005 proposed three design strategies: design for dismantling, where building materials should be technically easy to separate, design for deconstruction, where building components should be technically easy to disassemble and design for adaptability, where buildings should be technically easy to adapt to changing constraints. [2] Debacker added another design strategy: design for versatility, where buildings are designed for versatile use. [3] To facilitate reuse on every building level a fifth design strategy can be added: design for disassembly, where slow and fast cycling elements need to be physically decoupled from each other, to increase the durability of components and the building. [4]

2.3 Time-based design approaches

Time-based design approaches are useful to design buildings, elements and components in order to assure the compatibility between the different basic components. Consequently the components can be reused after a life cycle in another combination and in another building. [5]

For example SAR, Stichting Architecten Research, developed in the sixties a design approach to adapt dwellings by disconnecting support and infill elements, applying a modular coordination system and the use of zones and margins.[6]
By separating support and infill, a user can change the parts of a building which have an influence on him, without touching the support, which is seen as something of the community.
The infill changes are made possible by a dimensional compatibility between infill and support, namely by a modular coordination system, based on a grid of 30 by 30cm; whereas the concept of zones and margins the design of the support facilitate by the aid of four possible zones separated by margins. [7], [8]

2.4 Open industrialisation

In order to rebuild dynamically in an efficient way the use of open industrialization is a necessity. By combining open industrialized components unique buildings can be made, and after a life cycle the building components can be reused and recombined to a new unique project.

By the use of open building systems an unlimited number of combinations of standardized components/elements is possible. The starting point differs entirely with closed and semi-open building systems, because first a set of elements are designed and then projects are made with those elements. An element catalogue gives an overview of all possible elements in the system; and the combination rules related to the applied grid, the positioning, etc. can be found in a design guide.

Open industrialization is one step further: products of several open building systems can interchange by using agreements and rules concerning modular coordination and joining for the whole building sector. By these agreements building elements of different suppliers are compatible. [7], [9], [10]

3 ANALYSIS CASE STUDIES

3.1 Introduction

Despite the fact that time-based architecture has several ecological, economic and social advantages and that there is already a theoretical foundation by design approaches and strategies, the application of time-based architecture in Belgium and over the whole world is still limited to a negligible percentage of the total constructed patrimony.
To understand why this is the case, some well-known international case studies of the 20th century are discussed in this section. The design of the selected case studies is each time based on one or several foregoing time-based design approaches or strategies; and those case studies had always a large market in mind. However the production was for most of the selected case studies restricted to just a few implementations or it has never been more than a prototype or a design, due to various difficulties.

3.2 General panel system

The general panel system (1943-1944) by Walter Gropius and Konrad Wachsmann is based on the packaged house system, an earlier design of both. With this three-dimensional modular timber construction system small buildings could be made. The elements are connected with hooks and cotters. (Figure 1)

The general panel system needed fewer elements and used better joining techniques than the packaged house system. The intention of Gropius and Wachsmann was to create a completely prefabricated building system, which easily could be put together by unskilled workers without

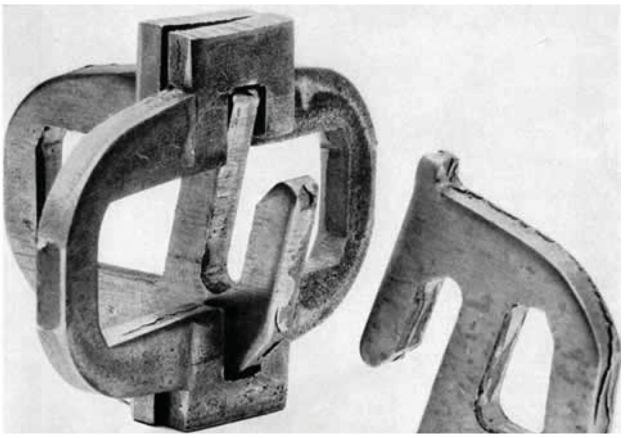


Figure 1: Joint of the general panel system. © Akademie der Künste, Berlin, Konrad-Wachmann-Archiv

Figure 2: Wichita house. © Beechcraft Photo

specific knowledge or skills. With the aid of the system any building could be built up to two storeys high. The sophisticated design limited the construction time to just 36 hours.

The system was eventually sold approximately 175 times. The higher costs compared to conventional timber frame systems was the principal reason of failure. Moreover, there was a lack of collaboration between production and design. [11]

3.3 Wichita house

The Wichita House was designed by architect Buckminster Fuller in the period of 1944-1946 in cooperation with the Beech Aircraft Company. Wichita is based on an earlier design of the architect, namely the Dymaxion House.
Buckminster Fuller wanted to make a house designed as a car by utilizing mass produced components that are easy to maintain, and can be replaced and reused.
The joining of the components was designed to facilitate repetitive assembly and disassembly. Assembly and disassembly would also be possible by one person in six days, because of the minimal weight of the components. Namely each component should weigh less than 5kg.

The original plan was to erect 200 houses a day, but the design went never really into production. Only two prototypes of the original design were made. (Figure 2) A third hybridized version was constructed in 1948 and was the only inhabited Wichita House.
This failure has not one specific reason. One of the causes was the fact that it was not adaptable to different sizes of households, different programs, and economic means. Another reason for failure was the futuristic design of the dwelling; it has no connection with its (historical) environment.
Additionally, Buckminster Fuller had a difficult personality.
He wanted to decide personally on any decision, which delayed the design and engineering part. The design was eventually not developed enough to proceed to the actual production of Wichita.
The high investment costs involved for the Beech Aircraft Company didn't make it easier to realise a Wichita House and because of the start of the Cold War Beech Aircraft Company decided to no longer invest in civil building projects. [11], [12], [13]

3.4 Lustron house

After the 2nd World War the American government decided to subsidize housing, so veterans could buy quickly and cheaply a house. In this context, Carl Strandlund got the chance to develop a system by which an entire house could be made from prefabricated steel panels. With modular units shelving, closets and rooms could be made that were maintenance free.

With the aid of the system 6 different dwellings could be

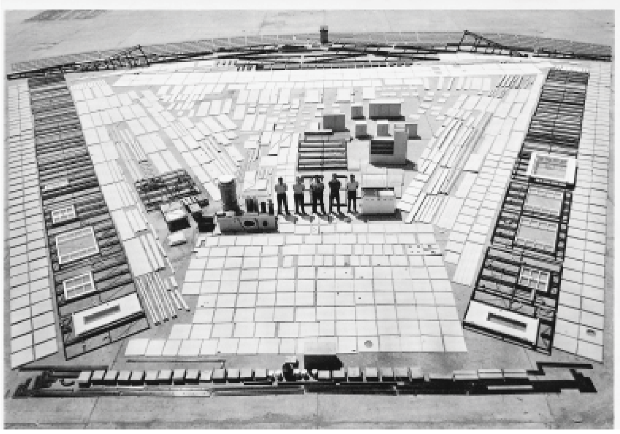


Figure 3: Pieces of a Lustron House. © Arnold Newman/ Getty Images

produced, in different colours.

All the parts of the house were transported by one specially designed Lustron truck and a house could be built in just 8 days.

After 2 years of production and almost 2500 houses later the company went bankrupt. The production rate appeared lower than expected, 20 dwellings a day were produced instead of 100. This made the production cost increase, namely up to 50% higher than expected. Moreover, the delivery of steel was irregular, that is why the guaranteed on-time delivery could not be realised.

Furthermore, the company had much opposition from construction trades and media, like for example Time Magazine called the dwelling a bathtub and a hot dog stand. The problem was that the Lustron House was too visible factory-made. Some states of the US even banned the Lustron House totally by prohibiting complete steel housing. [11], [14]

Additionally the system was characterized by a lack of variability, 'The whole was not greater than its parts'. (Figure 3) [15]

3.5 Shell system

Moshé Zwarts designed in 1967 for the employees of Shell a system with which dwellings could be made.

The system consisted of load bearing columns, situated in the façade and surmounted by steel trusses. The closure of the different spaces was materialised by interchangeable story-high wall panels, placed on a grid of 1m20. The panels are interconnected by cross-shaped columns, from which four orthogonal directions can be made. All panels can be moved, except those of the wet cells.

The building system was used for the construction of two bungalows and a petrol station. (Figure 4) There were designs for more projects, but none of them were realized.

Figure 4: Shell dwelling. [16]

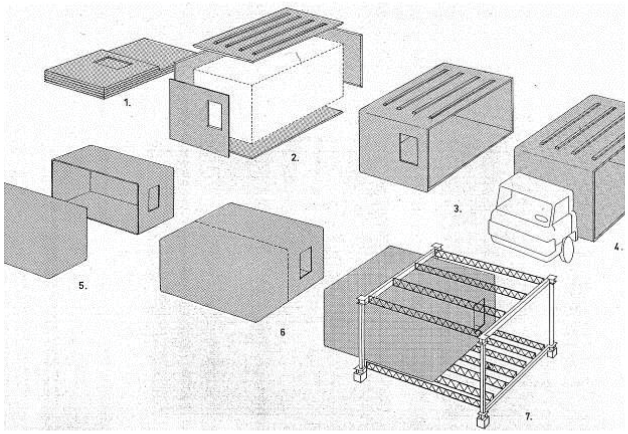


Figure 5: The installation of a Fokker module and the placement in the frame. [17]

According to the creator of the system, it wasn't the quality of the system that was the culprit, but the fact that 'the system' was too visible. [16]

3.6 Fokker dwelling

In the 60s the Dutch Royal Aircraft Factory Fokker wanted to differentiate their production more by developing a competitive housing system, as they got fewer orders than before to build airplanes. The company showed interest in a design of Johan Schepers, who was then a student. The design consisted of completely rigid box-shaped modules. [17] A module can function as an independent dwelling or can be connected to other modules. These modules are placed in a steel construction frame and because the steel skeleton was completely separable with the modules, the modules could be removed and reused after use. (Figure 5) In this way a dwelling can enlarge and shrink. Additionally, the infill is completely separated from the module.

The student design was further developed into a real home by a team of the company Fokker. First, a half module was built on real size, followed by a complete test dwelling. Afterwards, the detailing was refined, but the realisation of the project was postponed and eventually aborted.

The mean reason the project didn't had any real realisations, was the fact that at the time the company wanted to go into production, the aircraft industry knew a revival and the company no longer wanted to invest in additional projects. But another quite interesting reason was that local authorities sometimes didn't grant building permissions. [14]

3.7 Matura

Time-based architecture not only failed at building level; the Matura system is a more recently example of a failed building product.

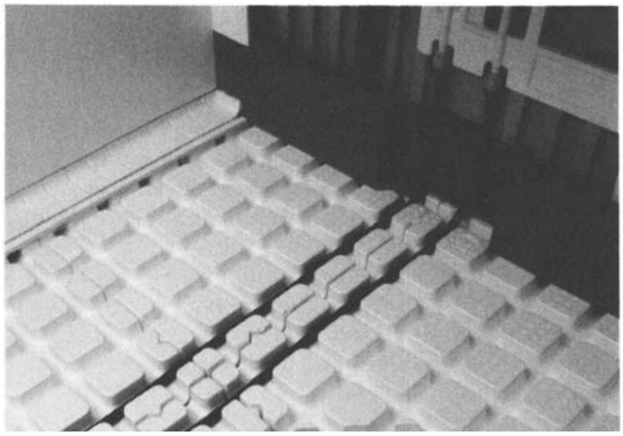


Figure 6: Matura matrix tiles. [18]

Figure 7: A Sekisui house. [20]

The intention of Matura, designed by Age van Randen and John Habraken in 1990, was to adapt techniques freely, so the layout of a building could be freely adapted too. This was achieved with the aid of a ‘matrix tile’. This insulating tile had grooves on both sides, which prevented tubes not to cross each other. (Figure 6) On top of the tiles a protective polyurethane finish was placed.

The main advantage of the system was the speed of building and the biggest drawback was the finishing layer. Namely, this layer must be broken open whenever changes were needed.

At first Matura had success in Berlin, but elsewhere the company didn’t break through. [19]
This was because the profit of the contractors partly went to Matura, who didn’t wish to act as a contractor. This met with resistance by the contractors and so the product was not accepted by the market. [14]

3.8 Successful projects

Of course not all time-based projects failed. In [14] the authors describe eight customized industrial projects, including Fokker House and Matura, like discussed above. Of those eight only two were successful: the Habitat complex (1967) of Moshe Safdie and the Sekisui houses (1950) (Figure 7), which are more traditional stand-alone houses; namely, the appearance of the Japanese Sekisui houses does not reveal the completely industrialized fabrication process of the modules and an important quality of the Habitat complex is that it is built as a project and not as a system; perhaps this made its success.

3.9 Belgium

It can be noted that no projects discussed above are situated in Belgium. The reason is that hardly any time-based projects are located in Belgium.

Galle discusses in his thesis two Belgian time-based projects: La Maison Médicale of Lucien Kroll and Hypothecaire Belegginskas of Willy Van Der Meeren. [21]

In both buildings the principles of SAR are applied, in the project of Lucien Kroll this is not done blindly. For example, the architect does not work with zones and uses a grid of 10 cm with a preference for multiples of 30 cm. The partitions can be exchanged and reused on the entire grid.

The limited number of time-based projects in Belgium can have several causes. The most obvious reason can be found in the Belgian predilection for building with bricks. In Belgium is solid masonry the most used construction method, while time-based building systems often are steel (skeleton) based.

Another possible reason is the high number of renovation works compared to the total number of given building permissions [1], since many time-based products only are applicable to new constructions. Because there is

	Design	Adaptability and variability	Aesthetics	**Marketing**	Marketing strategy	High investment/initial costs	**Cooperation**	Production and policy, people	Production and design
Wichita	•	•	•	•		•	•		•
Panel				•		•	•		•
Lustron	•	•	•	•		•	•	•	
Shell	•		•						
Fokker							•	•	
Matura	•	•		•	•		•	•	

Table 1: Reasons for failure.

each year less free space, the percentage renovation is increasing each year, in Brussels it was in 2011 as much as 90%. Admittedly, the share is in the other regions still relatively limited (approximately 50%), but the actual share is probably higher since not for every refurbishment work a building permission is required.

3.10 Conclusions

The analysis of the case studies brought out some difficulties of implementing (re)build dynamically. Some projects failed or were never realized due to inadequate marketing strategies, poor design and/or limited cooperation between different stakeholders. (Table 1)

A common problem is the design of the used building systems. They are often not adaptable enough; there is only one type or a group of similar buildings possible. In other words, the used building systems are closed or semi-open. Additionally, the projects often don’t have any link with the environmental and historical context of the building.

The second group of reasons for failure is related to wrong chosen marketing strategies and high investment/ initial costs. Namely, the marketing of time-based architecture needs a different approach than conventional building products, because of the high initial costs on the one hand and lower maintenance costs on the other hand.
A lack of cooperation between production and design and between production and policy is another problem in several cases. Cooperation from the beginning of a design is necessary.

In Belgium, time-based architecture is limited to a few projects. This may be related to the specific context of Belgium. There is the tradition of solid masonry, while time-based architecture often is based on steel skeleton structures.
In addition, time-based building systems are useful for new construction projects, but they rarely offer solutions for renovation projects. This is problematic for Belgium, because of the high percentage of renovation projects.

4 A FRAMEWORK TO (RE)BUILD DYNAMICALLY

4.1 Introduction

In this part a framework is proposed to implement (re) build dynamically in Belgium. The framework is considered as a valorization process from theory to practice. It makes a gradual transition towards practice by going through different stages whereby more and more stakeholders, companies and persons are involved in each stage.

The valorization process starts from static closed and semi-open building systems. In the short term dynamic open building systems will be reached, so that finally in the long term dynamic open industrialisation will be achieved. (Figure 8)

The following paragraphs describe the different stages of the framework, namely the preliminary stage, fundamental research, demand-driven research and the development stage; more in detail.

4.2 Preliminary stage

In the preliminary stage, the research steps of the next stages are being determined by the (market) leaders of various stakeholder groups.

By seeking collaboration from the beginning between all stakeholder groups, among which researchers, contractors, manufactures, designers, user groups and government integral building, product and marketing solutions will be reached. (Figure 8: a)

4.3 Fundamental research

This stage consists of fundamental research within three disciplines: marketing, evaluation and design. (Figure 8: b) The necessary research is accomplished by several research institutions.

Possible evolution scenarios need to be analysed and an evaluation tool has to be created, which can evaluate the obtained solutions in the next steps both financial and environmental.

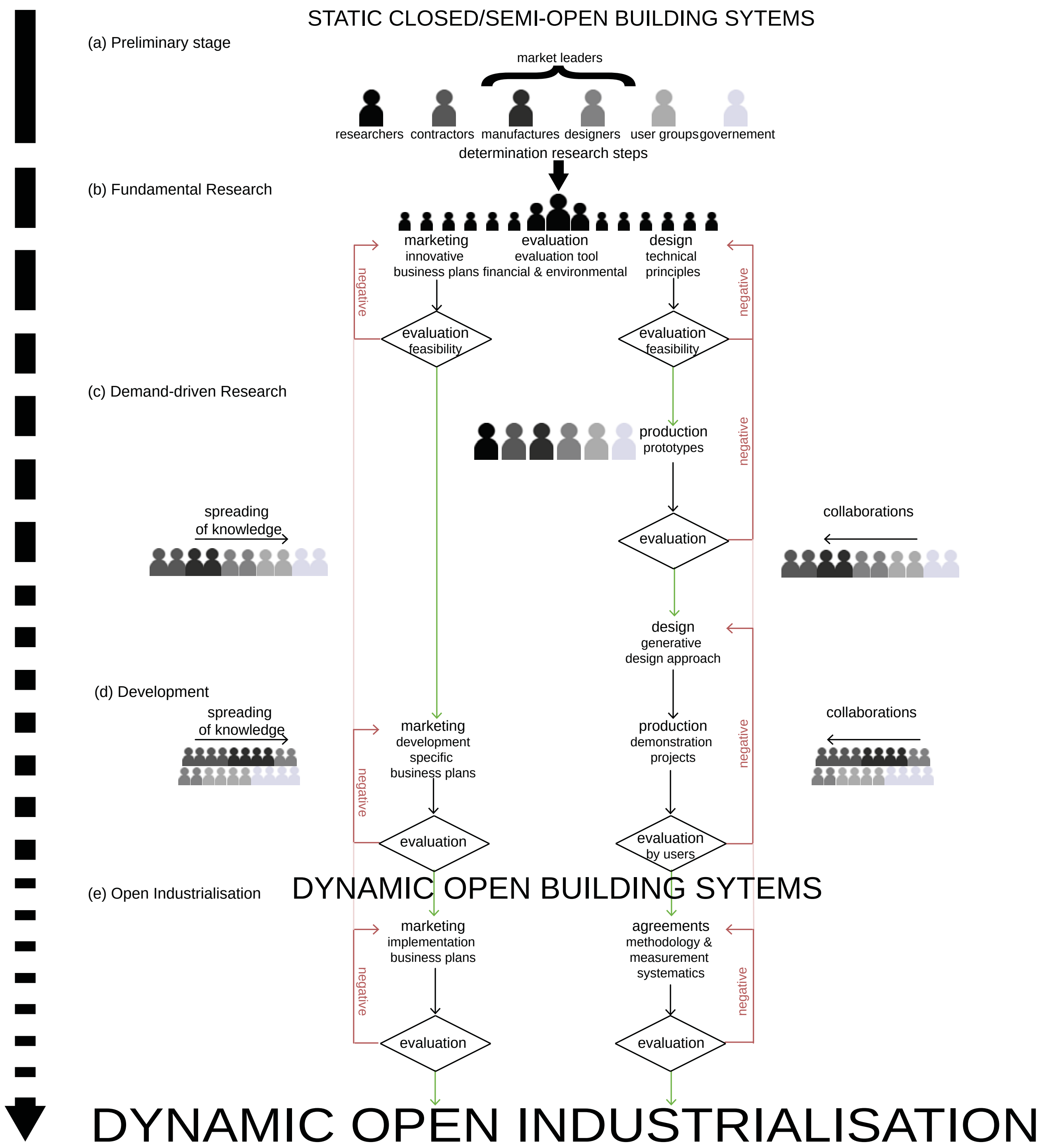


Figure 8: Conceptual framework.

Innovative business plans need to be examined by researchers specialized in marketing, like for example the opportunities of product-service systems and mass customistization need to be investigated. The feasibility financial and environmental of those business plans will be evaluated.
In the design part, technical principles, based on existing building systems and products, are developed, in order to separate the different building layers and to deconstruct building components. The feasibility of those results will be evaluated too.

4.4 Demand-driven research

Several prototypes of dynamic building products, based on the technical principles previously found, are developed in collaboration with representatives of all stakeholder groups in the next research step. If the prototypes are positively evaluated, a generative design approach will be developed; if not, the technical principles of the first research step will be revised.

To involve more people the gained knowledge will be spread to a wider audience of manufactures, designers, etc. (Figure 8: c)

4.5 Development stage

In the next stage demonstration projects are constructed with a dynamic open building system, based on the developed generative design approach, and in collaboration with several building sectors. Those projects are evaluated by users and other stakeholders. If necessary the generative design approach will be improved or if there are problems on a higher level the technical principles will be revised.
Those demonstration projects will make dynamic rebuilding known by the general public.

In addition, specific business plans are developed and evaluated. (Figure 8: d)

4.6 Open industrialisation

Finally open industrialisation is reached by all building sectors by making agreements about methodology, measurement systematics and connections.
The developed business plans are implemented and a final evaluation will be made of both disciplines. (Figure 8: e)

5 CONCLUSIONS

By utilizing the proposed framework a gradual transition towards time-based architecture is possible. The transition is enabled by finding dynamic solutions based on existing building systems and products. This allows more traditional dwellings and buildings in general, being built; so people are not deterred to implement those solutions.

6 ACKNOWLEDGMENTS

This research is funded by IWT, Agency for Innovation by Science and Technology in Flanders.

7 REFERENCES

[1] Eurostat, 2008, Eurostat, Waste statistics - long-term trends. [Online]. Available: http://epp.eurostat.ec.europa.eu/.

[2] Dorsthorst, B. J. H., Kowalczyk, T., 2002, Design for Recycling, in Design for Deconstruction and Materials Reuse, USA/Germany, CIB Publication 272, 71–81.

[3] Debacker, W., 2009, Structural Design and Environmental Load Assessment of Multi-Use Construction Kits for Temporary Applications Based on 4Dimensional Design (PhD Thesis), Vrije Universiteit Brussel, Brussel.

[4] Durmisevic, E., 2006, Transformable Building Structures (PhD Thesis), Technische Universiteit Delft, Delft.

[5] Debacker, W., Henrotay, C., Paduart, A., Elsen, S., De Wilde, W. P., Hendrickx, H., 2007, Four-dimensional Design: From Strategies to Cases - Generation of Fractal Grammar for Reusing Building Elements, International Journal of Ecodynamics, 2/4: 258–277.

[6] Habraken, N. J., Valkenburg, B., 1972, Support: An Alternative to Mass Housing, London, UK, Architectural Press.

[7] Henrotay, C., 2008, A Contribution to an Integrated and More Sustainable Design Approach for the Material Support of Shelter After Disaster, PhD, Vrije Universiteit Brussel, Brussels, Belgium.

[8] Boekholt, J. T., 1987, Ontwerrpprocessen, Ontwerpmethodieken, Eindhoven, Technische Universiteit Eindhoven.

[9] De Troyer, F., 2002, Ontwerpgids - Bouwen Met Prefab Beton. FEBELCEM.

[10] Frampton, K., 1995, Moderne Architectuur - Een Kritische Geschiedenis, Nijmegen, The Netherlands, SUN.

[11] Staib, G., Dörrhöfer, A., Rosenthal, M., 2008, Components and systems: Modular Construction, Basel, Birkhäuser.

[12] Bergdoll, B., Christensen, P., 2008, Home Delivery: Fabricating the Modern Dwelling, 2/1, New York, The Museum of Modern Art.

[13] Design 4 Deconstruction, 2012, Dymaxion House - Buckminster Fuller. [Online]. Available: http://www.design4deconstruction.org.

[14] Eekhout, M., Verkaik, K., Haagsman, E., 2005, Towards a Customized Industrial Concept House: Research, Development & Design for a New Generation of Customized Industrially Produced Houses in Western Europe, in Proceedings of Concept House, Delft, Netherlands, 5–28.

[15] Kieran, S., Timberlake, J., 2004, Refabricating Architecture: How Manufacturing Methodologies Are Poised to Transform Building Construction, New York, McGraw-Hill.

[16] Moshé, Z., 1990, De Techniek Van Damocles, in Tussen Traditie En Experiment: Over Ontwerpens, Ontwikkelaars En Ondernemers in De Bouw, J. Westra, Ed. Rotterdam, Uitgeverij 010, 57–62.

[17] Westra, J., 1990, Voortrekkers En Volgers, in Tussen Traditie En Experiment: Over Ontwerpens, Ontwikkelaars En Ondernemers in De Bouw, Rotterdam, Uitgeverij 010, 12–16.

[18] Vreedenburgh, E., Mooij, M., van Randen, A., 1990, Leidingsystematiek in Relatie Tot Flexibiliteit: Verslag IOP-onderzoek, Technische Universiteit Delft.

[19] Leupen, B., 2006, Frame and Generic Space: A Study into the Changeable Dwelling Proceeding from the Permanent, Rotterdam, 010 Publishers.

[20] Beemster, W., 2000, Bouwen in Japan, Nieuwegein, Arko Publishers.

[21] Galle, W., 2011, Time-based Design: Over De Aanpasbaarheid En Het Ontwerpen Van Gebouwen (thesis), Universiteit Gent, Gent.

DEVELOPMENT OF A DECISION SUPPORT MODEL FOR DETERMINING BUILDING LIFE CYCLE STRATEGIES IN THE NETHERLANDS

S. Binnemars[1], J.I.M. Halman[1], E. Durmisevic[1]

[1]Department of Construction Management and Engineering, University of Twente, Enschede, Overijssel, The Netherlands,

s.binnemars@utwente.nl, j.i.m.halman@utwente.nl, e.durmisevic@utwente.nl

September 2012

Abstract

In recent years, it became apparent that there is a serious need for green buildings with a lower environmental impact during the complete building life cycle. The construction industry craves for strategies that support a drastic change of the way we develop, construct and maintain buildings. However, the problem with current developments is that the new building concepts are too much an evolution of traditional building systems, which not necessary lead to the intended shift towards green transformable buildings. The goals for this research are to acquire knowledge about the impact of specific design characteristics on the complete building lifecycle, develop possible scenarios to create green transformable buildings and determine how the various strategies relate to the building lifecycle. An additional goal is to create knowledge about how to measure the effectiveness of the chosen strategy. The expected result of this research is a decision support model for conceptual building. The model should lead towards a better understanding of innovative green solutions for buildings and therefore create a better opportunity to innovate. This paper describes the research design.

Theme: *Green Buildings and Architecture*

Keywords: *Conceptual Building, Building Lifecycle, Life Cycle Strategy, Measurement, Decision Support Model*

1 INTRODUCTION

This paper describes the research framework of a PhD project at the University of Twente about the development of a decision support model for determining building life cycle strategies in the Netherlands.

The main question of the research described in this paper is: How to design, construct and maintain green buildings throughout the complete building life cycle? This question does not have a simple answer; it does not even have one solution, as the result is dependent on the function of a building, the way the building is used, the location and so many other factors.

In the last 25 years, it has become increasingly clear that sustainability is necessary if we want to maintain the current level of civilization. Humanity is at an increasing rate polluting and destroying the earth.

Since the need for sustainability became more accepted, the greatest contributors to pollution also started becoming visible. In recent discussions it is said that the construction industry in combination with the built environment have a very high impact.

To cope with this high impact, many different studies have been performed into a range of specific areas. This resulted in a lot of unstructured knowledge about design approaches, production efficiency, better building lifecycle performances, and reducing the spilling of materials. Now it is time to combine the knowledge to make a leap in the development of the construction industry by guiding the decision making process. In order to do so the scientific knowledge must be understandable for the construction industry. Therefore, it is necessary to combine and translate the acquired knowledge into terms of; goals, strategies to achieve those goals and insight in the effects of those strategies on the goals.

The first part of this paper – section 2 and 3 – explains the key driving factors of innovation and problems in the construction industry, the second part – section 4 and 5 – is an evaluation about what is done to deal with the key driving factors and reflection on these solutions. In the last part – section 6, 7, 8, 9 and 10 – the opportunities, objectives, research design, goals, benefits and deliverables of the research are described.

2 WHY WE LIVE IN AN UNSUSTAINABLE WORLD

2.1 Resources

We live in a world with roughly two kinds of materials, regenerative and non-regenerative materials. Sometimes it is chosen to use regenerative materials in a rate faster than the regeneration rate. In that way even the regenerative materials will not last. For materials, which are perceived as non-regenerative, there is a Peak oil theory (Hubbert 1956) about the mining of the materials. There are roughly three phases in the mining of natural resources. First exponential growth of output, then a phase of stabilization of output and lastly a decline in output. (Figure 1) This theory is also applicable on other materials. As for now, we live in a positive part of the shard where new deposits are found and the output is increasing, however when we pass the peak the abstraction of the material becomes harder and more expensive. Eventually the material will be depleted or too expensive for practical use.

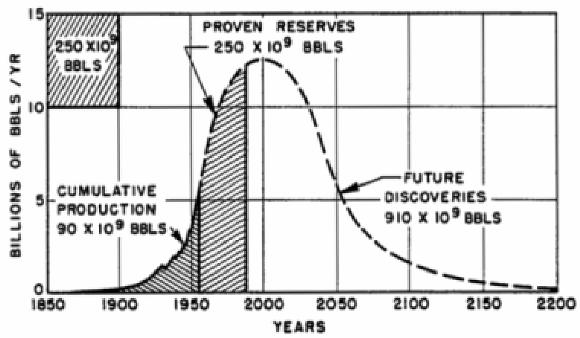


Figure 1, Peak Oil Graph (Hubbert 1956)

In 'Limits to growth' (Meadows, Randers et al. 1972) the rapidly growing world population is connected to the finite resource supplies. Examples are the limits to food production and problems induced by industrialization like pollution, and resource depletion. In 'Cannibals with Forks' (Elkington 1997), 'Collapse' (Diamond 2005), and 'A New Green History of the World' (Ponting 2007) the authors state that society is able to choose to be sustainable or unsustainable. Nevertheless, when they choose to be unsustainable this will eventually mean their downfall. Scarcity of materials could be a cause for problems in the construction industry.

2.2 Environment

The Brundtland report "Our Common Future" pleads for sustainable development. The report warns for:

- Acidification of Forests and Lakes
- Depletion of Ground Water
- Desertification of productive dry lands
- Destruction of Forests
- Energy shortages
- Environmental Degradation
- Erosion
- Food Security
- Increase of Poverty
- Global Warming
- Loss of Species and Generic Resources
- New Chemicals and New Forms of Waste
- Overpopulation
- Ozone Layer Depletion
- Pollution of Air and Water
- Proliferation of Toxic Chemicals and Hazardous Wastes
- Toxic Substances into Human Food Chain and Underground Water Tablets.

The authors of the report state that these points most likely will cause problems in the future. (World Commission on Environment and Development. 1987)

In 'Small is beautiful', Schumacher (1973) places criticism on western economics. Modern economy is unsustainable because natural resources are treated as expendable income. The problem is that most of the resources are not renewable and will eventual be depleted. In addition, he states that the resistance to pollution of nature is limited.
Rockstom et al.(2009) published their first article about what they call planetary boundaries. They aim to quantify boundaries of the planet (Figure 2). These boundaries should not be crossed in danger of losing the relative stable and ideal living conditions, which are present on earth since the start of the Holocene. However, the problem is that we already crossed four boundaries, namely; Climate Change, Ozone Layer Depletion, the Nitrogen Cycle and the Rate of Biodiversity loss. Luckily, by regulations and political action currently the boundary of Ozone Layer Depletion has been brought back within the threshold and the Ozone Layer is recovering. The problem is that when a boundary is crossed too far or too long the climate on the planet can change drastically. This means that every human development should be evaluated against these nine boundaries.

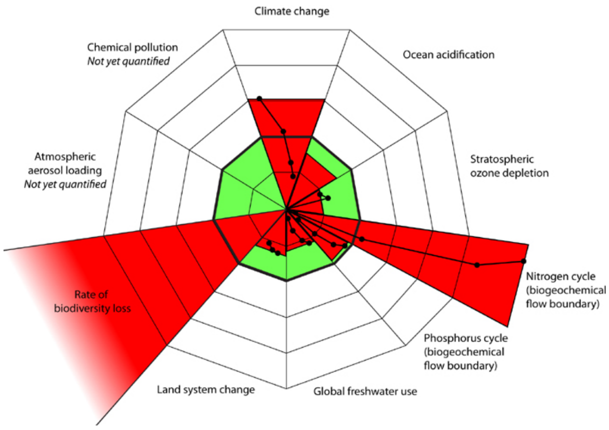


Figure 2, Nine pillars of the stability of the environment (Rockström 2009)

In short, the construction industry has to act and develop with those potential problems in mind.

2.3 Economy

In the eighteen years from 1990 to 2008 the total number of building permits is slowly declining from 37,845 to 34,735. In this period the number of permits for new buildings dropped from 28,058 to 18,320 and the licenses for other reasons, e.g. renovation, grew from 9,787 to 16,415. The crisis, which started in 2008, however, made a serious impact on the building industry. The total number of licenses has since dropped from 34,735 to 22.717 of which 12,205 are for new buildings and 10,512 are for other reasons (CBS 2012). The economy put additional pressure in an already declining market. Competition has become fierce and price driven. One can conclude that good positioning in this market is important to survive.

2.4 Society

Properties of the Society

Society is subject to change, this can be observed by the population breakdown of the Netherlands (CBS 2012) in Figure 3. In addition, the household size has dropped from 3.93 persons per household in 1950 to 2.22 in 2010. (CBS 2012) From the combination of these two observations one can conclude that housing needs have changed over the past 60 years.

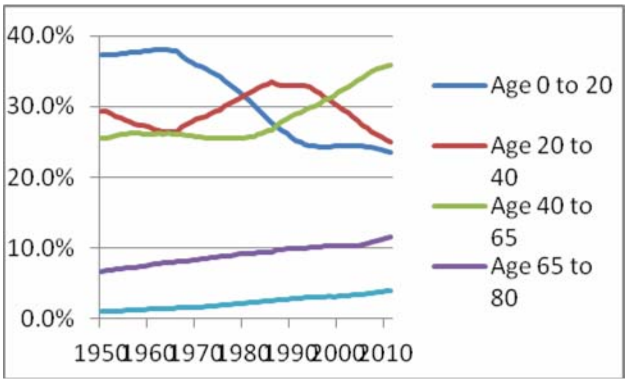


Figure 3, Population Breakdown by Age from the Netherlands (CBS 2012)

Needs of the Society

Maslow's Pyramid (Maslow 1982), where in the western world the physiological and safety level were always taken for granted and peoples struggles were of the love/belonging, esteem or even self-actualization level. Nowadays problems arise at the safety level. One can think about Security of Employment, Property, and

Resources. If we continue to deteriorate the world, we might even end up struggling to fulfil the physiological needs of food and fresh water security.

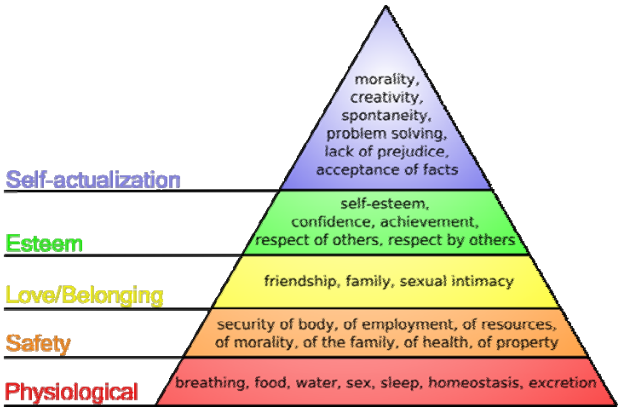


Figure 4, Maslow's hierarchy of needs (Finkelstein 2006)

The construction is directly affected by the people living in and using the buildings. When the needs of the people for living environment change this is likely to have an impact on the construction industry.

3 CONSTRUCTION INDUSTRY AND THE BUILT ENVIRONMENT

3.1 Current impact of the Construction Industry and the Built Environment

In the Official Journal of the European Communities is stated that:

> "The residential and tertiary sector, the major part of which is buildings, accounts for more than 40 % of final energy consumption in the Community and is expanding, a trend which is bound to increase its energy consumption and hence also its carbon dioxide emissions" (Council 2003)

This fact can only lead to one conclusion: the construction industry has to lower its footprint of energy usage and CO_2 production.

3.2 Construction Industry and Economy

Money is created by debt with buildings as pledge, the value of buildings was too high, now the pledge appears to be of a lower value. This in combination with mortgages, which could not be paid, led to the crash of the housing market. Since money is created by debt and people pay off their debt without getting new mortgages the amount of money is reducing.

3.3 Fixation creates a balancing problem

The inability of buildings to change functionality, which is a common attribute of buildings, creates a problem now. There are too many office buildings, which are not used anymore; on the other hand, there are too few houses for starters.

3.4 Innovation in the Construction Industry

Up until the 20th century improvements in the housing system were mostly based on the use of new materials or expanding the capacity. Since the second half of the 20th century, there is a constant drive towards the improvement of the performance of the building. Developments like for instance: sound insulation, fire protection, reduction of energy consumption for heating, communication techniques, and home automation all added to the performance of the building, but they all did so by adding materials or subsystems. These innovations did not lead towards a fundamental new building methodology. Instead, the only thing, which was done, was adding lots of new technology. This is called 'innovation by addition' (Lichtenberg 2004). Innovation through addition has led to the enormous complexity of buildings, reducing the adaptability.

4 DEVELOPMENTS IN THE CONSTRUCTION INDUSTRY IN THE NETHERLANDS

Although a lot appears to be wrong with the construction industry there are also positives. Several attempts have been made in order to deal with the previous mentioned problems. This section shortly introduces Green Architecture, Industrial Production, Sustainable Construction, Flexible and Adaptable Buildings, RGVO and Design for Disassembly.

4.1 Green Architecture

Green Architecture, architecture which aims for sustainable buildings, although becoming more and more important is nowhere close to being a standard. Green Architecture enhances Energy & Water Efficiency and applies Renewable Energy into buildings. Furthermore, Green Architecture makes use of Environmentally Preferable Building Materials and Specifications, Reduces Waste Generation and reduces the use of Toxics. Other key factors are a focus on high Indoor Air Quality, Smart Growth and Sustainable Development.(EPA 2012)

In short, Green Architectures aims to reduce stress on the environment and resources while creating healthy buildings.

4.2 Industrial Production

Industrial production has been practiced on a large scale since the Second World War. The mayor benefits of Industrial Production are economy of scale, higher efficiency, therefore reduced stress on resources, higher quality because of the conditioned production environment. It did however cope with some problems, the mayor problem is the repetitive designs, they were so boring people did not like those buildings at all. (Scheublin 2006)

4.3 Sustainable Construction

Sustainable Construction aims to increase the performance of the construction process by reducing the CO_2 output, energy use, waste generation, etc. This approach improves the quality of the buildings and at the same time reduces the impact on environment. Sustainable Construction, although promising, is still quite new and under development.

4.4 Flexible and Adaptable Buildings

Improving adaptability and flexibility increases the value of the building and its components & elements. In addition, the increase of the adaptability creates freedom of expression for owners. The combination of these two ensures a longer lifetime for the applied materials, which reduces stress on natural resources.

4.5 RGVO (Dutch Acronym for Result Aimed Property Maintenance)

The application of RGVO prevents unexpected high costs during the use period. This is done by measuring and acting in time. Also, this ensures a certain quality level throughout the life of the building. (Sprong 2009)

4.6 Design for Disassembly

Design for Disassembly improves the ease of assembly and disassembly, which enhances the reusability of components (Durmisevic 2010). Therefore, the value of components and elements will increase and the end of life waste generation will be reduced. The ability to disassemble a building enables the reuse of components – which reduces the stress on natural resources – and adaptability to the changing society.

5 HOW TO PROCEED

The current developments in the Netherlands are focused on reducing, reducing and recycling. Whether this is the appropriate approach is arbitrary. We could learn a lot from the Cradle to Cradle approach (Braungart and McDonough 2002), and aim for a positive footprint. Cradle to Cradle aims for a cyclic economy where the output of one process is at the same time the input for another process. A positive footprint means producing abundance, which is used as input for other processes or in generally seen as a good thing. Two examples of a positive footprint are: the cleaning of fine dust from the air and using CO_2 in the production process. This might not only apply to CO_2, fine dust and energy, but to all aspects, environmentally, economy, society (Binnemars 2011)

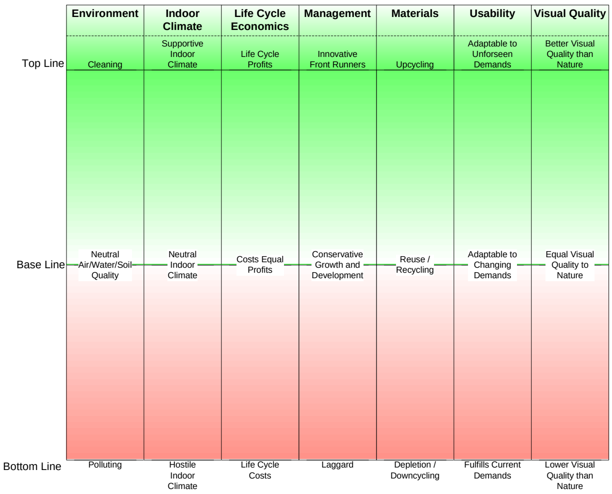


Figure 5, Example of a Conceptual New Sustainability Perspective (Binnemars 2011)

A broader perspective about green buildings, like the diagram in Figure 5, could help in determining directions for further development, innovation and research. The diagram depicts a space from the bottom line, via the base line to the top line. The Bottom line can be seen as bad, e.g. polluting, bad climate, bad visual quality etc. The base line is currently seen as sustainable, e.g. CO_2-neutral, energy neutral, economically neutral, etc. The Top line aims for a positive impact, e.g. CO_2 absorption, creation of a healthy environment, economically beneficial, upcycling, etc.

6 OPPORTUNITIES TO MAKE A LEAP TOWARDS GREEN BUILDINGS

Although there are many challenges, there are also many initiatives and opportunities to learn. For this research a lot can be learned from the experiences with existing innovative building methodologies. Furthermore, other industries, which are technologically ahead of the construction industry, can prove to be inspiring. Moreover, this research can use previous studies to support theories and provide arguments for experiences with existing methodologies.

6.1 Learning from existing innovative building methodologies

A lot can be learned from existing building methodologies and their successes and failures. For example: Open Systems Building (Habraken 1972), Wilde Wonen (Weeber and Vanstiphout 1998), IFD(SEV 2001), Slimbouwen (Lichtenberg 2009), IDF (Binnemars 2011) and Living Buildings(de Ridder 2011).

6.2 Technomimicry

Also, a lot can be learned from more industrialized high tech branches like the automotive industry, the industry for household appliances and the computer industry. One of the most common used strategies is development following the Product Platform Development principle, e.g. (Veenstra 2006). Another important development is the adaptation of Cradle to Cradle (Braungart and McDonough 2002) in products and production processes.

6.3 Scientific researches

Lastly a lot can be learned from studies performed in the field of construction, but also from researches about other fields. This knowledge can then be combined towards applicable knowledge for the construction industry.

7 THE OBJECTIVE FOR THIS RESEARCH

The objective for this research is to develop a decision support model for sustainable building concepts. This will require knowledge of existing strategies and measurement. Based on that a clear overview about which additional research has to be done in relation to missing strategies or measurement is necessary. In order to reach that objective there are four sub objectives: develop a model for the building lifecycle, create a matrix of possible strategies, determine the relations between strategies and the building lifecycle phases, and finally determine possibilities to measure the effectiveness of the strategies on the building lifecycle.

8 WHO WILL BENEFIT FORM SUCH A RESEARCH?

Besides the goal, the benefiters are also very important since they are the reason for the research. This research aims to place specific knowledge in an overview which is helpful for science, the decision support model is supposed to be a useful tool for the construction industry, and a healthy construction industry will help the society.

8.1 Science

Primarily science benefits from this research. Considering the combining of previous specialized researches, tapping into other pools of knowledge, which are not directly related to building and construction, and revealing gaps of knowledge.

8.2 Construction Industry

The construction industry also benefits from this research. There will be a clear overview from the current state of development and a broader perspective to be able to decide which direction for innovation is preferable to pursue. Furthermore, the model can be used to reflect upon and improve the current business strategies.

8.3 Society

The society benefits from a healthy construction industry by a healthier environment, more jobs, better job security, high quality buildings with high quality architecture and high indoor climate quality.

9 RESEARCH DESIGN

9.1 The Research Design

The researched is designed in such a way that knowledge is gathered according to necessity. Each phase provides input for the next phase. (Figure 6) This makes it crucial to follow the steps in this order. Also, the phases are specific enough to have a clear start and finish which allows a project approach for each phase. The phases are designed as a pyramid; each phase should provide a good foundation for the next layer. (Figure 7)

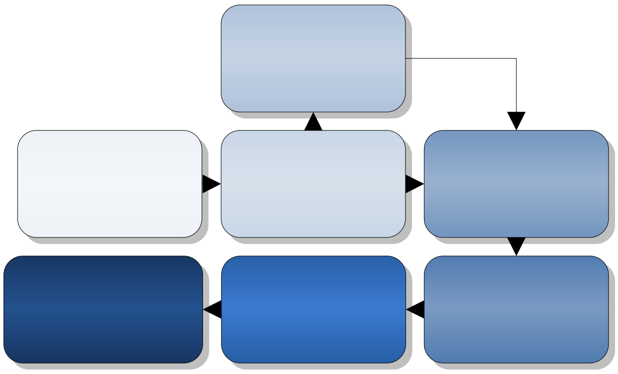


Figure 6, Research Design route

Phase two, three, four and five will generally consist of the following steps:

- Setting the goals for the phase
- Describe how to reach the goals
- Develop a planning with Deadlines for the goals
- Gather the necessary data
- Interpret the data
- Develop a model
- Write a Paper about the findings

9.2 Phase One

Phase One is all about the research design. The expected result is this paper and a more detailed phase to phase description of the research. The focus of the research design is developing a clear overview about which knowledge is needed at what time in the research.

9.3 Phase Two

The purpose of phase two is creating knowledge about the complete building lifecycle. This knowledge will be presented in a model including material, money flows and actors. This is necessary to determine the influences of strategies on the building lifecycle (phase three).

9.4 Phase Three

In this phase a research will be performed into possible strategies for different parts of the building lifecycle. Strategies will be collected and linked to the lifecycle model.

9.5 Phase Four

After creating knowledge about the lifecycle, strategies and the relations between those two, this phase will search for methods of measurement to rate the effectiveness of those strategies.

9.6 Phase Five

When all information about the lifecycle, strategies and measurement is collected this will finally be combined in a model which supports design decisions for conceptual building.

9.7 Phase Six

After the model creation, this phase consists of the testing and validation of the model followed by remodelling.

9.8 Phase Seven

Finally conclusions and recommendations will be made about the process and the results.

10 EXPECTED RESULTS

There will be three mayor results provided by this research. The first will be the pyramid of knowledge about strategies for sustainable buildings – which is created over several phases – the second result will be a matrix of sustainable building strategies – which categorizes strategies based on attributes and shows which are missing – and the final result will be the decision support model for determining which lifecycle strategy is the most sustainable for a specific situation – which can be used by the construction industry – .

10.1 Pyramid of knowledge

The pyramid is symbolic for the knowledge created in this research. To get the best results in each layer a thorough knowledge about the layers below that layer is necessary. The first level aims for complete understanding of the building life cycle, the second level aims for understanding of the applicable strategies, the third level aims for understanding of the relations between strategies and the building life cycle, the fourth layer aims to measure the effectiveness of the strategies and the top layer aims for understanding about which strategy reaches the best result for a certain desire.

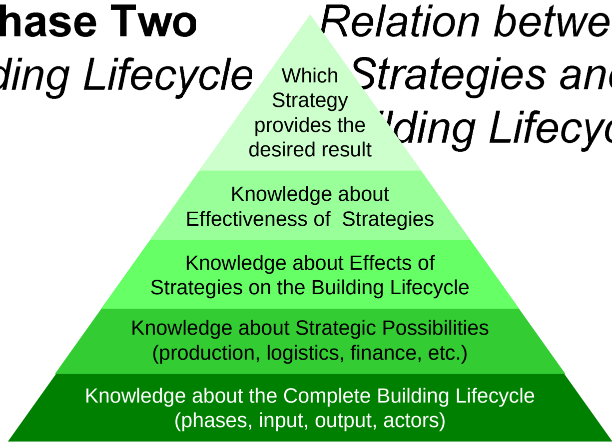


Figure 7, Knowledge Pyramid

10.2 Strategy matrix

The strategy matrix will be developed in phase three and completed in phase four. One axis of the matrix will list the different life cycle phases and the other axis of the matrix will list the effects on these phases. The matrix will be filled in with strategies. In this way it will be easy to observe which effects are not yet addressed by a strategy. This information can be used for directing further researches.

10.3 Decision Support Model

The last result will be the decision support model. This model should be easy to use. The aim for the model is to calculate which strategy is most suitable considering input parameters. The output of the model is a generated list of the most suitable strategies and the explanation why this is the case. Figure 8 shows a flowchart of the model.

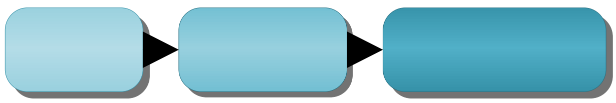


Figure 8, Graphic representation of the model

11 ACKNOWLEDGMENTS

We extend our sincere thanks to all who contributed to making this project available, and in special Jeroen van Dijk and Wim Sturris from the Van Dijk Groep B.V.

12 REFERENCES

Binnemars, S. (2011). Guiding the Construction Industry towards more Sustainable Building. CTW | IDE. Enschede, University of Twente. **Master Thesis**.

Braungart, M. and W. McDonough (2002). Cradle to Cradle, Remaking the way we make things, North Point Press.

CBS (2012). Building Licenses: Value and number according to the kind of building(Bouwvergunningen:waarde en aantal naar soort gebouw).

CBS (2012). CBS StatLine - Average population; sex; civil class; age and region(Dutch: Gemiddelde bevolking; geslacht; burgerlijke staat, leeftijd en regio). CBS - Home.

CBS (2012). Population; Corefigures (Dutch: Bevolking; Kerncijfers). CBS StatLine.

Council, E. (2003). Official Journal of the European Communities. Directive 2002/91/ED of the european parliament and of the council of 16 December 2002 on the energy performance of buildings. **46:** #65-71.

de Ridder, H. (2011). LEGOlisering van de bouw; Industrieel maatwerk in een snel veranderende wereld, Mauritsgroen.

Diamond, J. M. (2005). Collapse, How Societies Choose to Fail or Succeed, Viking Press.

Durmisevic, E. (2010). Green design and assembly of buildings ans systems. Saarbrücken, VDM Verlag Dr. Müller Aktiengesellschaft & Co. KG.

Elkington, J. (1997). Cannibals with Forks, the Tripple Bottom Line of 21st Century Business. Oxford, Capstone Publishing Limited.

EPA, U. (2012, July 19). "Components of Green Building | Green Building | US EPA." US Environmentals Protection Agency. Retrieved September 10, 2012, from http://www.epa.gov/greenbuilding/pubs/components.htm.

Finkelstein, J. (2006). Diagram of Maslow's hierarchy of needs. Inkscape. 800px-Maslow's_hierarchy_of_needs.png.

Habraken, N. J. (1972). Supports: an alternative to mass housing. New York,, Praeger Publishers.

Hubbert, M. K. (1956). "Nuclear energy and the fossil fuels." (95).

Lichtenberg, J. (2004). Slimbouwen©, a rethinking of building, a strategy for product development, Eindhoven.

Lichtenberg, J. (2009). Slimbouwen, Enschede.

Maslow, A. H. (1982). Toward a psychology of being. New York, Van Nostrand Reinhold.

Meadows, D., J. Randers, et al. (1972). Limits to Growth. New York, Universe Books.

Ponting, C. (2007). A New Green History of the World. London, Vintage.

Rockström, J. e. a. (2009) Planetary Boundaries: Exploring the Safe Operating Space for Humanity. Ecology and Society

Scheublin, P. I. F. J. M. F. (2006). INDUSTRIEEL BOUWEN, WAAROM EN HOE, Eindhoven, Universiteitsdrukkerij TUE.

Schumacher, E. F. (1973). Small Is Beautiful: Economics as if People Mattered. London, Blond & Briggs.

SEV (2001). Demonstratieproject IFD-bouwen 2000.

Sprong, R. K. (2009). Leidraad resultaatgericht vastgoedonderhoud.

Veenstra, V. S., Halman, J.I.M. and Voordijk, J.T. (2006). "A Methodology for Developing Product Platforms in the Specific Setting of the Housing Industry." Research in Engineering Design **17**(3): 157-173.

Weeber, C. and W. Vanstiphout (1998). Het wilde wonen. Rotterdam, Uitgeverij 010.

World Commission on Environment and Development. (1987). Our common future. Oxford ; New York, Oxford University Press.

GREEN ARCHITECTURE & GREEN CITIES
THE UNIQUENESS AND DISTINCTIVENESS OF URBAN AND ARCHITECTURAL HERITAGE OF BOSNIA AND HERZEGOVINA
AS A ROADMAP TO BIOCLIMATIC ARCHITECTURE AND SUSTAINABLE URBAN DEVELOPMENT: SYMBIOSIS OF TRADITION AND FUTURE

Dr. Denis Zvizdić
Faculty of Architecture in Sarajevo, Bosna and Herzegovina

Abstract

The character and universality of urban and architectural heritage of Bosnia and Herzegovina, is contained in its essence (spatial structure and function, structure and design, internal logic of spatial organization, human scale and visual aesthetic messages including inspiring complexity and layered meanings). Urban planning and architecture are the spatial and material projection of socio-economic, cultural and political circumstances and necessities of life in a certain space and time. This actually implies a philosophy of life, ethical and moral values of the time in which we are born, live and die. It is necessary to conduct the urban and architectural heritage valorization that will results universal messages from the heritage, thus they could be continuously transposed in the new, and with modern trends compatible, spatial, formative, environmental and visual expression. This paper will give overview of urban and architectural heritage of Bosnia and Herzegovina built during different periods through history that give us lessons as basis for further development of cities.

Keywords:
Architectural and urban heritage of Bosnia and Herzegovina, Medieval fortresses of Bosnia, mahala, carsiya, bioclimatic architecture & sustainable urban planning and development, urban metabolism, green cities

1 INTRODUCTION

Urban planning and architecture are the spatial and material projection of socio-economic, cultural and political circumstances and necessities of life in a certain space and time. This actually implies a philosophy of life, ethical and moral values of the time in which we are born, live and die.

It is clear that the most striking examples of urban and architectural design were always, closely and unambiguously, associated with the social structure, customs, religion, ruling policies. In that sense, the most crucial connection was the relationship of the local population to the living environment.

Special roles in such processes have natural and cultural monuments which constitute the material, and spiritual values of every city and every state. Those monuments enrich the contents of memory and the silhouette of the urban fabric and its material and symbolic-expressive interpretations create a staunch supporter of national and cultural identity. Within this cultural heritage an urban and architectural ensemble of monuments has the specific artistic quality which has been proven through lasting time and space duration. Therefore, people with a developed civilization, culture, tradition and awareness on the importance of architectural heritage, properly apply in their contemporary practice "layers" of urban, architectural and cultural tradition. By undertaking the reconstruction, rehabilitation, or reminiscent in the scope of overall architectural intervention, respecting of the context and continuity is the most important link in the chain of affirmations and tracing of new models for "intervention".

Urban and architectural heritage of Bosnia and Herzegovina, in the logic of its spatial structure and function, structure and design, internal logic of spatial organization, human scale and visual aesthetic messages, includes inspiring complexity and layered meanings. The traditional approach, to urban and architectural space and structure, shows a remarkable sense of understanding the sound relationship to nature, climate and topography. This confirms the wisdom, imagination, knowledge of skill builders, which is a stimulus and source of inspiration for a contemporary practice in planning and building design. This is evident of the dialogue with the ambience in terms of architecture on a human scale and harmonious integration into the environment that leads us to the realization of a reasonable synthesis of traditional and contemporary architecture and design and the need to create humane relationships between man, space, ambience.

1. VALORISATION OF URBAN AND ARCHITECTURAL HERITAGE OF BOSNIA AND HERZEGOVINA

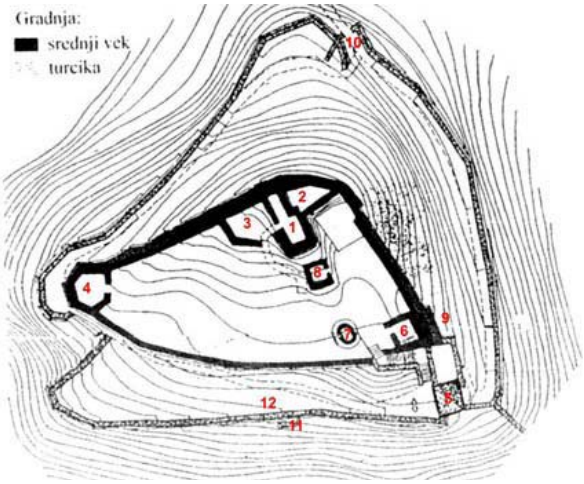
There are numerous representative examples that, in general, interpret and confirm the value of B&H architectural heritage in special organization, as well as in the construction practice. As the first, it is necessary to mention the medieval towns - forts which represent a true pearl of architectural and building heritage.

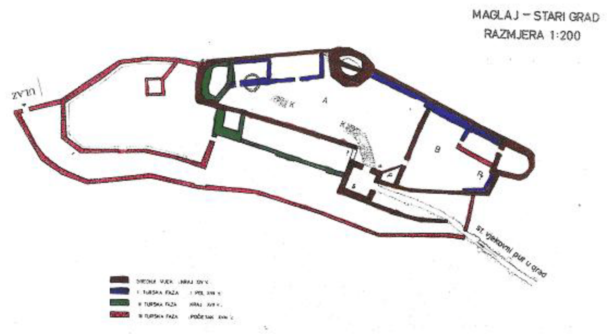
Here, then, we wish to underline the guise fortified cities (location, disposition, materialization) as a highly readable and sublimated expression of the unity of the natural and social environment, on one side and of human hands creations, on the other side. Medieval towns, forts, feudal nobility habitats, are unique jewels of architectural heritage. It is a set of rulers' habitats of certain territories that provides all goods and conditions necessary for the life of the entire population, as well as and for the master

who, to preserve the leading position framed territory by dams.
The uniqueness, which is needed to highlight, is the spatial-functional-material appearance of fortified towns (location, disposition, materialization). This represents an extremely readable and sublimated expression of the unity of natural and social environments. *("Every medieval town has sprung from a unique situation, provided a unique constellation of forces and created, in his plan, a unique solution"* [10])3
The city is now called the fort, blended into the landscape of stone and masonry; it encompasses the tower (s) and, later, the bastion. The tower (initially only one, and later, two or more towers connected by walls, but always only one was the main) was a central object around which all the other "urban" and institutional attributes gathered. Towers have always been built of cut stone foundation and they, in principle, had circular or square layout. Around the tower is a courtyard surrounded by a massive wall that rises to a height of 15-20 meters and has its foundations in the lower part (which is used for defence) very tick, 3-5 meters, while the wall thickness decreases as the wall rises in height. Floors, which are used for housing, have wooden or vaulted ceilings, located at high above ground level (first floor was usually about 7-10 meters above the ground) and have only the most essential fittings.

Illustration 1: Bosnian medieval cities, symbiosis of natural and built environment. Source: B (c,e,m,u)

The purpose, therefore, determined the character of the city (fortress-sentry, fortifications, barracks for the accommodation of the entire army or a fortress-palace where he lived a nobleman), its shape and size (square or round, usually, oblong) and the method of construction was exclusively tied to the natural site conditions (terrain configuration has always been one of the most important parameters of the process of locating and spatial orientation of the city, especially the tower) or materials that could be taken directly from the immediate environment.





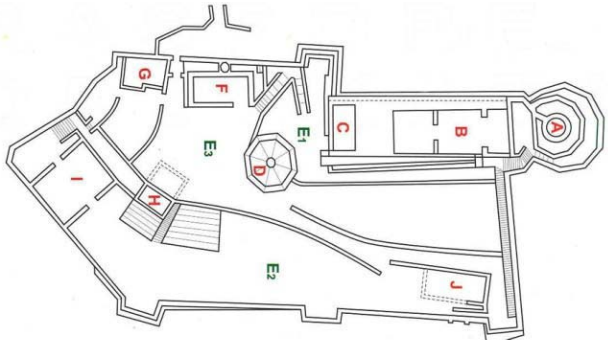


Illustration 2: "The old towns built in the 14th & 15th century: Doboj, Maglaj, Travnik"
"Sensible and creative town planning - architectural concepts in the context of environment and identity." Source: [B] (c, y)

All this, in line with the customs of the people who work there, or live around it, a sense of security as one of the primary function that has been provided to its residents, and the organization that provided intimacy and collectivity, as well as the individual and social planning, was a creative and intuitive approach that has resulted in symbiosis of built and natural environment.5

Because of that, these fortifications should referred as the "founder of the family tree", weaved into the appropriate memory through vitalization of function that should be an integral part of the complex life of cities.

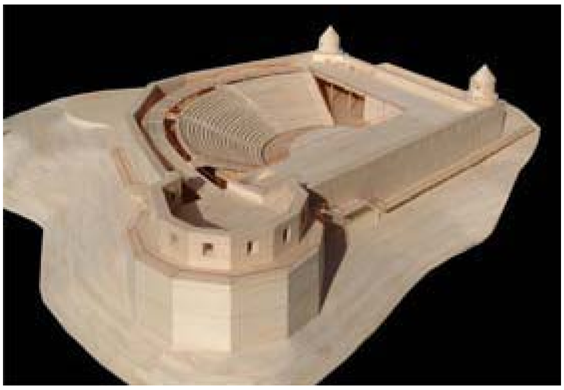


Illustration 3:

V. Kladuša & Banja Luka & Sarajevo: positive examples of urban renewal - renewal of medieval fortresses and cities, as new building structures, and as well as social corrective. Source: [B] (aa,nn)

Special attention to the extraordinary range of indigenous Bosnian architecture testimony, deserves traditional rural architecture, its inventive construction, the placement of houses and ancillary facilities, exceptional functionality, the materials used, the spatial disposition, is also a very important part of the rich mosaic of traditional architectural heritage; thus it confirmsthe quality and it reflects the approach in designing and constructing that is harmonized with the natural and social realities of the region, places and times.

Illustration 4:
"guest house -" cooperation with nature and create a living environment where everything is subordinated to the needs of users, the lives of nature and with nature, man, takes the user but not threatening, not harm, do not disturb the established harmony. " Source: [B] (c, e, q)

Country houses, as main goal, always had satisfaction of needs and desire of "cooperation" and spontaneous harmony with nature. They builders created a living environment where everything was subordinated to the needs of users and in line with the simplicity of the governing philosophy of life and traditional - convenient customs and habits.
Everything in these houses is extremely simple, functional and rational and yet, in the material-formal and artistic expression, in particular, stimulating and inspiring. The house is an inseparable part of the natural environment and visual experience, with the rational design and informal structural system; forms of houses, their disposition and number of floors are adapted to man and his family, their needs, customs, culture.
The natural materials used in construction are a product of logic and rational thinking of the rural people (this is the nature with which he lives, which gives him all that he needs, depends on what he have taken from her, but non-violently, just as much as he needed).
Thus, rural architecture of Bosnia and Herzegovina sends outstanding lessons arising from symbiosis with nature and life of nature; man – user takes, but not threatening, not harming, not disturbing the established harmony, and also improves and builds what the nature has already made and which he knowingly and without damage, adapts to his needs.
The mills, as well, represents examples of the sensitive approach to natural resources, wich means to
architecture, which in its philosophy carries lessons for creating and defining the principles of formation of the spatial and architectural art inherent for BiH.

Illustration 5:
" Mills at Pliva & Buna" - biological basis, synthesis and utility of imagery, a structural and landscape architecture
Source: [B] (c, f)

Water mills, depending on whether were built on the river or creek, and depending on the general terrain configuration, always "pulsed" with the natural environment in which they were built. They were constructed of local, raw materials and fully adapted to their function; convert the water power for basic needs of man-user.
In fact, every urban and architectural intervention in the concrete place requires studious analysis of the spatial locations and the dialogue with the surroundings. In this process we do not only come to know about the architectural features of the past times but we face with socio-cultural and civilization architectural message in the urban tissue, analytical registering component parts of the existing urban units.
Thus, every architect, the creator who scientifically and professionally analyzes and evaluates the traditional

building in Bosnia and Herzegovina comes to the realization that it offers a wealth and variety of creative incentives for modern architecture.
One of the best examples of Bosnian urban and architectural heritage, as a meaningful and educational integration of aesthetics, proportion, texture, plastic and natural environment within which and with which all this occurs, organically emerge, grow and coalesce in a single indivisible unit is ambiguously linked complex of town Oriental type houses that represents an inexhaustible source from which contemporary urban architectural creativity can draw already valorized and consequently imperishable lessons which, translated into principles of conduct in the construction of the built environment, can always produce new ideas incentive-based and aligned with the time-consistent premises contained the harmony between man, object and environment in which everything arises and everything happens*. (That is why the architecture is always tied to the land or for the "existential space" as a psychological concept which man creates and develops in contact with its environment* [11] *)*
Bosnian town house of the Ottoman period was formed under the ruling and dominant influence of Oriental culture, whiuch after the arrival of Ottoman Turks in our region, extending not only to art but also to all other areas of life (economics, religion, morality ...) but these effects were never simple logic transplanted and adopted, but they have always been mixed, and very often modified by local workers and kraftsmem. That's why we say that the "Bosnian" urban houses (in terms of its functionality, design and materialization), fully adapted to local needs and characteristics (logical architecture that is in the process of designing and creating useful spatial elements using local materials and experiences of local man and the soil where it originates, in which occurs, and most importantly - where will exist, and determining and defining impact on a number of other, closely associated with it, in accordance to human activities and needs), and that in some segments differs from classical Turkish home, because here, as in everywhere, a man of that time built his peculiar view of the world on the environment in which it operates.

Illustration 6:
„The logic of ambient integration, elementary functions, spatial organization and architectural design“.
Source: [B] (a,b,c, f,q)

One of the most important segments of the value of the ensemble of the Bosnian town house is its urban and landscape settings which are reflected in its interactive relationship with the immediate physical and natural environment and its role in the process of development of neighbourhoods (‘mahala’).
Specifically, the Bosnian town house, as a multi-layered, complex concept, represents specific physical entity on which, from many aspects, "public" and "intimate" overlapped, as the basic principles of Oriental approach to organization of the entire life of the Bosnian people, of neighbourhoods or ‘mahala’, or of small town or ‘šeher’. Such a division is taking place at the macro and micro level and, starting from the physical, dispositional, communication, etc. The functional division between public and private (intimate) part, carried out under the house and complex that it is included within its walls, it goes even further, and covering a larger spatial and urban areas as they neighbourhood (which again leads to the division of the public - transparent part of which consists of streets, alleys and 'čikma' (dead-end), and private - within the family of the house), to the level of cities - township and borough whose urban planning follows this by creating a matrix in its centre part of the public - in which the marketplace operates, traded, sold, bought, discuss, negotiate, negotiates, communicate, plan, etc. are welcomed, and within which there are shops, covered markets, khans, baths and other representative objects of which are critical 'mekteb' (religious school) and private - residential part of the settlement provided personalized to meet the needs of stay and residence as well as those functions that are most directly related to them.

Illustration 7:

the extraordinary value of the spatial-formal, plastic and visual creations that have emerged in the 'mahala' (neighbourhood) as a very expressive and harmonious spatial units. Source: [B] (c,d,q)

This different degree of transparency of public and private, in order to reflect the level of urbanization and materialization and the level of importance and bazaar quarter, is seen primarily in the use of materials and monumental buildings bazaar (mainly as a building material used stone as a symbol of strength, durability and the importance of such public and religious buildings) versus the degree of development and used materials in the process of house and neighbourhood. Of course, this is by no means must not ignore or diminish the extraordinary value of the spatial-formal, plastic and visual creations that have emerged in the 'mahala' (neighbourhood) as a very expressive and harmonious spatial units.
The process of development of mahala (neighbourhood), its degree of urbanization, planning and construction of the equipment and its contents are, as if an unwritten law, always similar if not the same for the Bosnian people, with built-in sense of placing the house in the countryside with full respect for the configuration , orientation and climate, are very simple.
Each “mahala” (neighbourhood) has its main street, which, from the standpoint of urban development and neighbourhood, its spatial arrangement, orientation or communication is the backbone or spine neighbourhood. Because of this, its dimensions are larger than any other communication, which are transport lines of average wide about 5.80 meters, on this main road is on the left and right, with the lower or upper side there lanes (on average 2.30 m wide) and dad-ends (average 2.15 m wide) along which now, respecting the right to view and respecting your neighbour, build a home base and the base cell of the new neighbourhood. Naturally, ‘mahala’ formally, is not formed until at its centre, in the best and most appropriate place cannot build a mosque at which, or the benefactor who built it, neighbourhood gets its name and which now, with its minaret as a recognizable and focusing Physical dominant, definitely "locate and create a" Mahalla.
The construction of the fountain, as the centre of neighbourhood’s public life and socializing, bakeries, barber and grocery, as public spaces, ending the process of the formation of ‘mahala’, which, by the then urban standards, with their 40-50 home, mosque, bakery, grocery, grave, etc. have all the necessary facilities and represented good concept where the whole space, the art of placing buildings and their adaptation field and the nature that surrounds them, and combining the standard compositional elements - gates, windows, roof - achieved very expressive spatial plasticity. Clearly, according to zoning and urban conditions, terrain and the necessary infrastructure, neighbourhood had spread, but still within the established principles of locating houses in the slope, or in a series of respecting the right to access and view. [4]10
Urbanized like this, and with a feeling for the terrain and the built environment, neighbourhood very easily integrate and fit into the wider urban area - a small town or ‘šeher’. Through such small town, as a spatial whole, neighbourhood transformed into an intimate part for living and for the satisfaction of public life, according to the size and importance of the city, the main street and bazaar represented multi-layered cohesive whole.

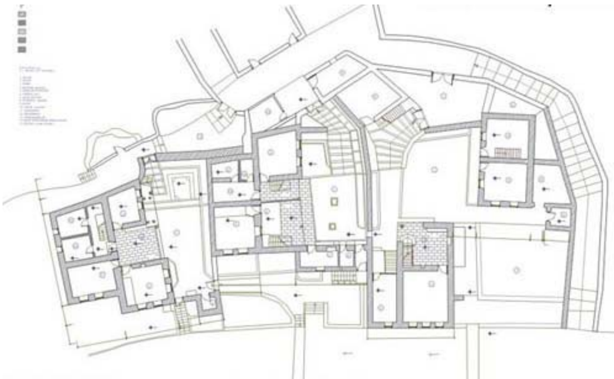
Illustration 8:
"The emergence and development of „mahala“ - the principle is unique: full respect for the configuration, orientation and climate" Source: [B] (a, c, bb)

Within this approach, and within such ambient whole attitude towards the natural environment was very important and bold line of oriental architecture. Here, of course, this does not reffer to the nature personified by stereotypical green, but thought the natural features of location, as well as through the atmosphere full of gardens, flowers, greenery, water and pleasure.

Man from the Orient never restricts the nature by artificially created canons and customs; on the contrary, he still leaves it as it really is - a wonderful, exciting and comfortable, fluid full of sensible feelings. Such a relationship could be viewed as a two-step interactive relationship: House - nature and family - nature, but never in any of their content and spatial organization, fully differentiated because cohesion of their parts is much stronger than individual, separated entities themselves.

The primary physical substantiality of ‘mahala’ (neighbourhood) consisted of oriental houses that essentially have been defined as an organic structure, and therefore in their efforts towards organic, integrated and expressive blend with the environment in which they occur spatially and compositionally developed more in width than in height, seeking and striving to adapt to the terrain and environment, with the sole desire of creating a symbiosis of man and nature that God has created.

All this had a clearly legible, the ultimate goal - integrating architectural - urban composition to nature, than, consequentlly nature transforms to architecture and the architecture becomes converted into plastics; (as Le Corbuiser stated: "Architecture is a question of plastic rather than romance").



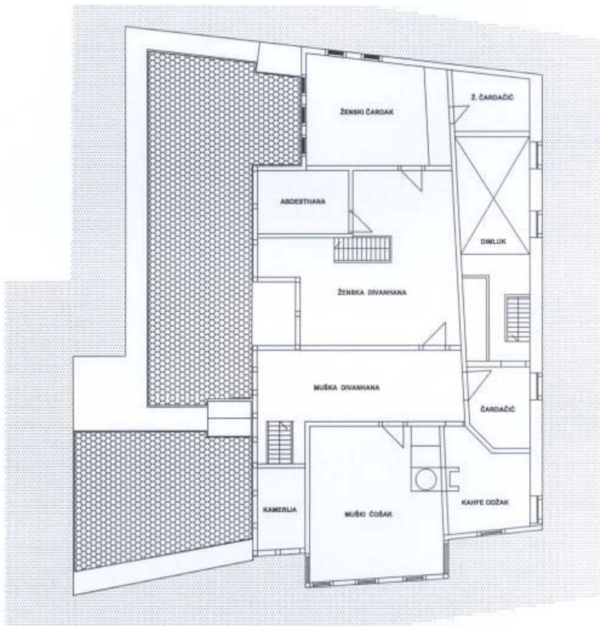


Illustration 9:
“Nature transforms to architecture and the architecture becomes converted into plastics”. Source: D.Zvizdić&[B] (a,b,aa)

That is why the Bosnian town house has been built with such rare sense of space and land, with great care, respect and responsibility in relation to neighbours. Although, from the standpoint of logical principles of construction, placement of houses on the slopes is done in cascades, such principles with the Bosnian oriental houses such were completely different, richer and more natural in their expression. These houses, especially in the visual-plastic expressions that one such agglomeration achieved, thrully belonged in the environment within they existed, as if they were grown from the earth and as if there are and always been standing ther, in terms of artistic and compositional experience they were indispensable compositional detail when, or if they were removed.

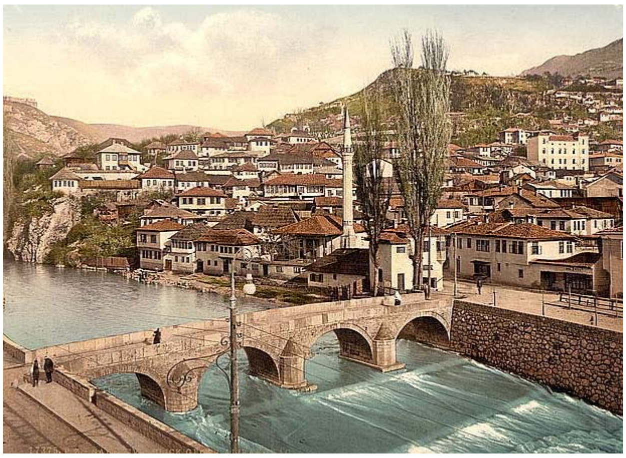


Illustration 10: Sarajevo & Počitelj: "the placement of objects in accordance with the configuration of the terrain". Source: Source: [B] (b, bb),

What is the most interesting is the fact that this subtle placement is not a question of a written law that "must" strictly comply, but above all, the inner experience of nature and the protective feelings towards the natural environment, deeply grounded in religious understanding and respect for what from God has been given to man.
For these reasons, the Bosnian man build light walls, bright, sunny and open houses, rich in its design, cosy and comfortable in its disposition and functionality, sensitive to its placement in the urban environment and within the nature around them.
This statement has its practical foothold in some of the basic compositional, functional, structural, material and formal elements of the house, as defined in the segment:

- correct positioning in the relation to bioclimatic factors and geo-morphological characteristics of the site;
- the functional organization of space, which is fully adapted to the proper orientation of the house in relation to the cardinal directions, which has arisen from the prevailing climatic conditions characteristic that resulted with different positional accommodation of spatial elements;
- sense of logic and decision making related to structural system, a rational approach based on composition of elements, structural assembly, use of raw-local materials, architectural design in the spirit of the time, location and environment;
- clearness in materialization of spatial elements and assemblies which now, according to climatic characteristics, can be more open (in Herzegovina) or more or less closed (in Bosnia); and
- shape and roof pitch, type of roofing materials - with roofs in southern areas where the dominant Mediterranean climate (Mostar, Stolac, Pocitelj ...) have a slight slope and are covered by the diagonal stone (due to rapid runoff of water and strong winds), while the house itself is more open to its interior encased in as much sun; on the other side, the middle and northern parts of Bosnia (Sarajevo, Travnik, Tesanj, Foca, Bihac, Cazin, ...) have a higher slope roofs (heavy snow) are covered tiles or shingles; here, the house is closed, but formally and spatially richer (verandas as a rule). Regardless the exact location, the axiom for construction of residential buildings is the same everywhere - a

symbiosis of the house and beautiful views, sunshine, greenery and nature.

Thus, the town house of oriental type in Bosnia and Herzegovina have its shape and layout characteristics adapted to climate, relief, and topographic features and in its consistency respect fundamental principles and axioms of traditional construction and placement, thus it "obeys" the specific characteristics of individual regions.

It should be noted that from the extraordinary, traditionally good neighborly relations that have been kept carefully, developed well-known "right to a view”, thanks to which, with the ambience and design standpoint, were created numerous picturesque villages, with astonishing artistic and utilitarian solutions, in the case of the creation and placement of Bosnian house, inevitably implying a sound relation between the architecture and life. [3]

Builder of the related time knew to set up house and yard in such a mutual spatial relations; house and street, a house and a settlement as well, so that each house, considered as a separate space - formal structures, according to their location received the best and most beautiful vistas. In fact, Oriental House seeks primarily view at the nature and the surroundings, in Mahalla, or market town, and no matter where it was built; a Bosnian man desired and provided sights. If it was built on the hill, received the coveted sight of the street, while a buildings along the street, got a look at the squares and the fountain. At any location the house has a sight, while the house itself was visible from the street or square. Neighbours who would later approached the building on one of these locations tried to build a house so it get betterand better sights, while this does not jeopardize the already acquired rights of its neighbours (and that was the unwritten rule is strictly observed, which should be respected nowadays, as well).
A practical and disciplined application of the "unwritten" rules resulted in a remarkable urban settings with subtle house placement (with an extraordinary sense for the location and surroundings), regardless of whether it is alternating a house, or other building on the slope with steep roads, or on the different dimensions of the upper and lower sides of the street, providing view on surrounding for each complex.
This rule (location and landscape placement of houses in the natural environment) is based on the aforementioned right to view and is very logical and the position of completely natural urban placements.

Differences arise only from the rule that you can locate the house on a slope or flat ground, but the architect’s task remains the same - that the house has an organic relationship with nature that ensures a free view at all sides. Where it was not possible, forming a oriel window was the solution, one of the most plastic details of Bosnian oriental houses. The result is outstanding visual art and urban agglomeration which is primarily characterized by setting sensible buildings in their landscape setting.

Illustration 11:
Travnik & Jajce, "PNV - extraordinary urban setting and the subtle placement of house"
Source: D. Zvizdić & [B] (d, f, bb)

Thus, the cognition of these values - lessons that the right to view, to the sun, to the cult of water, as well as harmonious integration of built into the natural environment, are in fact postulates of modern urban planning - urbanism in the service of men, and the achievement of visionary dimensions of space and universal values. Of course, any contemporary architectural intervention in the natural or urban tissues must be based on creative architectural feeling, in the spirit of the time and in accordance to the needs of modern life.
So, relation of the house towards the natural environment could be defined within:
- its placement in the immediate natural environment;
- relationship to the existing and newly planted vegetation
- establishment of gardens and fountains, as a symbol of life and enjoyment.
Based on facts elaborated above, it is obvious that Bosnia and Herzegovina has one of the most solvent urban and architectural heritage in Europe. Also the fact that the positive values of the architectural tradition are the inspiration for transposition into creative architectural synthesis between old and new, we are obliged to preserve and protect national and cultural identities, promote lessons of spatio-architectural heritage. This is all because only based on such attitude towards environmental and architectural heritage, an adequate guarantee for achieving intentions, such as human scale

urbanism and architecture in symbiosis with nature intact, could be provided.

2. LESSONS LEARNED FROM URBAN-ARCHITECTURAL HERITAGE AS A ROADMAP TO MODERN URBAN-ARCHITECTURAL CREATIVITY

Traditionally, urban and architectural heritage of Bosnia and Herzegovina consists of urban and architectural complexes and individual buildings that form the ambient "environment" as an expression of tradition, cultural and spiritual characteristics. That indigenous community, or area in which the identities of people were joining in the formal, material and environmental terms, was characterised by architecture that was permeated with human character and extraordinary plastic dimension. It is a creative concept and the emergence of subtle positioning of built into the natural environment, based on several (five) settings, including the most important: (i) harmonization with the natural environment, (ii) interactive interpretation and affirmation (in urban, functional, financial and formal sense), of ambient or building complexes and, very important social ethos, and (iii) retention of the recognizable expression of ambient and architectural identity within the existing micro and macro urban locations - agglomeration - region.
Thus, the spatial, formal, functional, material values of the spatial-architectural heritage, we find that the signs of the primary lessons that generate principles of future approaches to the built environment in the ambient space that is integrated into the environment in which it arises, of which it is necessary to emphasize the following:

2.1. Spatial - perceptual principles:

2.1.1. Sensible analysis of the geo-morphological quality sites; logical placement of buildings, namely bioclimatic characteristics as decisive factors for the emergence of urban planning and composition in order to achieve unity of architecture and nature

Each region has its own peculiarities, its own climate and topographic characteristics, socio-cultural and spiritual identity, all together, within their symbiosis, synthesis or simple interactivity, being the basis for creation of each segment of the physical organization of space.
Therefore, the location is, with the prior understanding of the essential ambiguity and complexity, and local and regional natural and human conditions, always in the most direct connection with the "architectural program", which forms a functional-structural purposes or urban areas, while the correct evaluation of the site (from the standpoint of natural: geotechnical, climate, vegetation, ...conditions; as well as from the point of created conditions: the history, traditions, architecture, economy ...), being an essential requirement in all phases of the emergence of physical structures in the area that always begins with a live "contact" with the location of future facility, with an intimate understanding of the environment within which the creative intentions are converted into concrete tangible form.
So, complete understanding of bioclimatic characteristics of micro and macro location (street, neighbourhood, village, city, region ...) where the facility occurs, especially from the aspects of:

• Geomorphologic, topographical and climate conditions; but also
• Its historical characteristics or traditional values, culture, and identity, or way of life based on 'unspoken' language of cultural values

All this should be a guarantee that entering the process of planning and construction will, as expected resulting, have the satisfaction of material and social needs of people and a balanced relationship with the natural and the urban environment and harmony in the local area (internal and external environment) without its degradation and the maximum of integrated conservation "of the urban character of the place" as well as the visual aspect of the function of the total value of the environment.

Accordingly, this imposes mandatory analytical "dialogue" with the location where the buildings, or architectural ensemble, should be created. All this must be aligned to social and geographic characteristics and to spatial-architectural analysis, so that environmentally sound urbanism and architecture could occur. [16]
Thus, proper, qualitative and sustainable urban solution must be sought in respect for the constitution of spatial elements, heritage values, the relationship between form and function, at a scale that is appropriate to the location and content.

2.1.2. Aligned relationship of the built and given environment to the needs of humans as social beings that are seeking "higher" quality of life through the optimal relation between the private and public, between the built and unbuilt, between interior and exterior

Understanding the nature of natural processes and the impact on nature and harmonization with nature as the source of all the most important resources: materials and energy, must be one of the basic postulates of contemporary urban and architectural creativity, because architecture is not only seen in the context of form, function, structure or design, but equally important within the spatial relationship with the natural environment.
In order to value heritage (lessons learned) and to accept and incorporate into all architectural delivery processes, an integrated approach is required. This is precondition for creating harmonized human surroundings in the context of the scale, proportional relationships and in the context of the optimal ratio of built to unbuilt - "preserved" natural - living environment. In order to achieve the aforementioned, it is necessary to:

• Achieve a balance with the natural environment in which the building or the built ensemble is formed with the sense of "use" and not "abuse" its capacity and resources, because the urban context is and must be based on the merits of the architectural definition,

• Achieve a balance in terms of achieving the necessary spatial and environmental substantiality of the building - the complex - the street – 'mahala' - quarter, as reported in ensuring the individual - 'inside' and the public - "outside" of space for yourself, family, friends, neighbours, the street-'mahala' and finally community

• Achieve the preconditions (in spatial sense) for future integration into a wider geographic coverage, because the principles of sustainable spatial planning does not mean to last just for the present moment, but it is, most of all, the planning for the future.

Contrary to these principles is reckless and "unnatural" relationship with nature, aggressive volume that ignores the basic characteristics of the environment and whose spatial relations are in complete disharmony with the natural environment in which they arise and therefore do not represent the humane and comfortable environment where users can meet their life needs.

2.1.3. **Humanization of the entire space as a prerequisite for the proper analytical approach to urban and physical design and its morphological structure, dynamic and interactive relationship of parts to a whole architectural composition within the ambiguous relationship of spatial organization, creation, function, aesthetic dimension, and finally the natural environment in which everything emerges, and where the everything occurs**

Proper zoning, or architectural design philosophy, that represents a creative and environmentally responsible planning and building, rather than building the template, inevitably involves community awareness and clear performance targets and relationship forms the building, environment, climate and tradition minimization the costs are put in the focus, efficiency, ease of use, functionality and user comfort.

2.1.4. **Human scale, the constituent elements of creative compliance in accordance with social, customary, cultural, religious characteristics and local peculiarities, the structural system based on authenticity, immediacy, and reasonable rules of construction and spontaneous and logical use of sound - natural building materials in relation to their structural- aesthetic properties**

Urban planning and architecture, inspired by the values of tradition and vision of modernity, must be in logical space, design, structural, material, dispositional and environmental segment and terms. This means: (i) build a high quality, durability and efficiency and minimize negative impacts on nature through the use of non-toxic and sustainable (local - natural) building materials and traditional construction while maximizing the energy efficiency of building the correct approach and implementation of each of the three parts of the energy triangle: the design, materials, construction, (ii) achieving a balance in the selection of building materials, infrastructure and construction systems and technologies in the sense of obligation to adapt their bio-climatic characteristics and capacities of local resources.
Elements of spatial concepts should be clear, logical, rational and recognizable, leaning on the values and lessons from the most representative examples of traditional architecture, while the proportions that constitute the internal spatial organization, form and composition must be derived from the intimate scale - man and nature, and which, connected with the appropriate history, tradition and spirituality, resulting in quality and physiognomy ambient space philosophy and beauty of the building and its simplicity of use.
Aforementioned elements of spatial concepts have always, in the composition of indigenous heritage and ambience, besides the use of natural materials and traditional construction, achieved an extraordinary shape and layout results with clear and effective artistic and aesthetic messages. The proportions derived from anthropological measures and human capacities and limits of the natural environment, using natural and healthy materials, "close at hand," whose warmth, structure and texture, quality and durability, with excellent structural properties, have exceptional aesthetic and visual quality. Built environment have been materialized spontaneously into unique spatial architectural composition on a human scale and its natural and social environment.

Proper zoning, or architectural design philosophy, that represents a creative and environmentally responsible planning and building, rather than building the template, inevitably involves community awareness and clear performance targets and relationship forms the building, environment, climate and tradition minimization the costs are put in the focus, efficiency, ease of use, functionality and user comfort.

2.1.4. **Human scale, the constituent elements of creative compliance in accordance with social, customary, cultural, religious characteristics and local peculiarities, the structural system based on authenticity, immediacy, and reasonable rules of construction and spontaneous and logical use of sound - natural building materials in relation to their structural- aesthetic properties**

Urban planning and architecture, inspired by the values of tradition and vision of modernity, must be in logical space, design, structural, material, dispositional and environmental segment and terms. This means: (i) build a high quality, durability and efficiency and minimize negative impacts on nature through the use of non-toxic and sustainable (local - natural) building materials and traditional construction while maximizing the energy efficiency of building the correct approach and implementation of each of the three parts of the energy triangle: the design, materials, construction, (ii) achieving a balance in the selection of building materials, infrastructure and construction systems and technologies in the sense of obligation to adapt their bio-climatic characteristics and capacities of local resources.
Elements of spatial concepts should be clear, logical, rational and recognizable, leaning on the values and lessons from the most representative examples of traditional architecture, while the proportions that constitute the internal spatial organization, form and composition must be derived from the intimate scale - man and nature, and which, connected with the appropriate history, tradition and spirituality, resulting in quality and physiognomy ambient space philosophy and beauty of the building and its simplicity of use.
Aforementioned elements of spatial concepts have always, in the composition of indigenous heritage and ambience, besides the use of natural materials and traditional construction, achieved an extraordinary shape and layout results with clear and effective artistic and aesthetic messages. The proportions derived from anthropological measures and human capacities and limits of the natural environment, using natural and healthy materials, "close at hand," whose warmth, structure and texture, quality and durability, with excellent structural properties, have exceptional aesthetic and visual quality. Built environment have been materialized spontaneously into unique spatial architectural composition on a human scale and its natural and social environment.

2.3. Material, formative and functional principles of perception:

2.3.1. Expression and feeling of the spatial, functional and formal design

The correct design presents the philosophy of the proper construction and not the building by the pattern, inevitably involving the community awareness and the clear performance targets as well as the connections of the forms of the building, the environment, the climate and the tradition by putting on the first place the minimizing of the cost, efficiency, simplicity of use, functionality and comfort of the user.

The elements of the spatial concept should be clear, logical, rational and recognizable, reclining on the values or lessons from the most representative examples of traditional architecture, while the proportions that constitute the internal spatial organization, form and composition has to be derived from the intimate scale of - man and nature, and that are linked with the appropriate history, tradition and spirituality, and the same result by quality physiognomy and ambient environment philosophy or the physical beauty and simplicity of the buildings and of its use.

2.3.2. The understanding of the quality and the concept of the material, functional and energetic efficiency

The sustainable architecture has to be logical in the formal, constructive, material, disposal and environmental sense. This means: to build with high quality, durability and efficiency and to minimize the negative impacts on the nature through the use of non-toxic and sustainable (local - natural) construction materials and traditional construction while simultaneously maximizing the energy efficiency of the building by the proper approach and implementation of each of the three parts of the energy triangle: design, materials, structures.18

Therefore, it is necessary to use natural materials from renewable resources in a manner which is consistent with their natural characteristics, quality and limitations, materials that can be recycled and that have minimal toxic effects on the environment or materials which in their production process, methods of use, use and final destruction (if required and necessary) make the least possible damage to primary resources such as water, land and air.

At the same time, they should use constructions and circuits based on the unity of experiences and skills and the respect towards human nature which allow long-lasting Buildings, the minimum use of materials (use of constructive modular systems) and minimum energy consumption during the use of the building or the complex. The segment of minimizing of energy use, through the methods that preserve or eliminate the use of energy (which is, in practical terms, offering by traditional BH architecture, especially the town house of oriental type - varied layout techniques) is very important and if the same is needed for the heating, refrigeration, air conditioning, etc., then it has to be related to renewable energy sources such as sun and bio-energy.

Accordingly, we can conclude that the architecture, more than any other activity in space, presents a particular challenge in the field of sustainability. This means that the buildings that aspire to take the sustainable epithet have to be designed, materialized, effective and spatially integrated in accordance with the above-mentioned principles and they have to:

(i) arise as a result of processes that strive for integral quality and harmonization with the natural surroundings within which they arise and exist, including intimate understanding of the location and respecting of orientation, exposure and topographic configuration and the ruling climatic conditions;

(ii) respect the traditions, customs, cultural and spiritual values of the community, in short "*the spirit of the town*" where the built environment should arise,

(iii) to have effective design which in the most efficient way connect the internal and external environment and to achieve the symbiotic relationship between the spatial concept, the structure, the shape, and finally the regional "spiritual" principles presented in "*genius loci*" of places,

(iv) to built with quality, rationally use natural resources (use of natural - sustainable materials, a minimum consumption of resources and appropriate to it, the creating of waste) and to strive to reduce the excessive use of energy (to prefer renewable energy) and to improve the overall quality of the environment,

(v) to have, in the course of construction and especially during the use, the minimal impact on nature and the already built environment, direct natural environment and narrower and wider community including the integral protection of the ecosystems through carefully planning location and sustainable design that aims to user comfort and harmony of the built and natural environment.

References:

A. Books:

1. Bernik, S. *«Arhitekt/Architect Zlatko Ugljen»*, (Međunarodna galerija portreta, Tuzla, 2002.)

2. Čelić, Dž. *«Spomenici kulture i urbanizma»,* («Naše starine», knjiga III, Sarajevo, 1954.)

3. Grabrijan D. i Neidhardt J. *«Arhitektura Bosne i put u suvremeno»,* (Državna založba Slovenije, Ljubljana, 1957.)

4. Grabrijan, D.: *«Razvojni put naše savremene kuće»* («Građevinska knjiga», Beograd, 1973.)

5. Handžić, A., *„ O formiranju gradskih naselja u BiH u XVI stoljeću",* (Sarajevo, 1975.)

6. Jencks, C. *«Prisustvo u prošlosti»,* (Mladost, Zagreb, 1980.)

7. Kreševljaković, H., *„ Stari bosanski gradovi",* (Naše starine I, Sarajevo, 1953.)

8. Kurto, N. *«Sarajevo 1462 – 1992»,* («Oko», Sarajevo, 1997.)

9. Marasović, T., *„Aktivni pristup graditeljskom naslijeđu"*, (Arhitektonski fakultet sveučilita u Zagrebu, 1985.)

10. Mumford, L. *„Grad u historiji",* (ITRO «Naprijed», Zagreb, 1988.)

11. Norberg – Schulz, C. *«Stanovanje, stanište, urbani prostor, kuća»,* (Građevinska knjiga, Beograd, 1990.)

12. Norberg-Schulz, C ., *„Genius loci – towards a phenomenology of architecture"*, (Academy edition, London, 1980.)

13. Pašić, A., Idrizbegović Zgonić A., Kudumović L.: *Restoration of traditional housing complexes - case studies: Muslibegovic, Bišcevic-Lakšic,Gavrankapetanovic and Ramic street housing complexes (in Mostar and Pocitelj; Technics Technologies Education Management -TTEM, Volume 7, Number 2, 2012, pp 475-483*

14. Pašić, A.: *«Islamic Architecture an Bosnia and Hercegovina»,* (OIC, Researh Centre for Islamic History, Art and Culture, Istanbul, 1994.)

15. Redžić, H.: *«Studije o islamskoj arhitektonskoj baštini»,* («Veselin Masleša», Sarajevo, 1983.)

16. Salihović, H., *«Arhitektura: stvaralačka sinteza tradicionalno - savremeno»,* (CPU Sarajevo, Sarajevo, 2010.)

17. Sanković Simčić, V., *„ Revitalizacija graditeljske baštine: integracija staro-novo“,* (NNP Naša riječ, d.o.o., Sarajevo, 2000.)

B. WEB sources:

a	www.kons.gov.ba	v	www.banjaluka-news.com
b	www.sarajevo.ba	w	www.openbook.ba
c	www.bhtourism.ba	x	www.spomenici-sa.ba
d	www.zavicajnimuzej.com	y	www.iis.unsa.ba
e	www.turizam-bosna.com	z	www.ekapija.ba
f	www.jajceportal.com	aa	www.sarajevo-x.com
g	www.kljuc.ba	bb	www.muzej-rijeka.hr
h	www.bpkg.gov.ba	cc	www. A4a.info
i	www.zvornikdanas.com	dd	www.klix.ba
j	www.bih-x.info	ee	www.fipa.gov.ba
k	www.tesanj.net	ff	www.bhstring.net
l	www. bh.blogger.ba	gg	www.skyscrapercity.com
m	www.dobojskatvrdjava.ba	hh	www.spiritofbosnia.org
n	www.forum.bih.net.ba	ii	www.communityplanning.net
o	www.krajina.ba	jj	www.urban-age.net
p	www.turizam-tesanj.com	kk	www.foundationwebsit.com
q	www.hercegovina.ba	ll	www.sustainable-cities.eu
r	www.stecak.ba	mm	www.urbanecology.org
s	www.bihtimes.com	nn	www.sustainable.doe.gov
t	www.bascarsija.info	oo	www.sustainable-society.
u			

A compared payback time study of building envelope implementation in a sustainable regeneration intervention

A. Boeri[1], J. Gaspari[1], D. Longo[1]
[1]Department of Architecture,
University of Bologna, Bologna, Italy

Abstract
A growing interest towards the regeneration of the existing building stock is taking place in several European cities in order to face the need of a drastic reduction of energy demand and in order to provide new strategies for improving the quality of the built environment. The paper presents a part of the results of a research, lead by the University of Bologna, concerning the cost effectiveness evaluation of technological solutions to be adopted in retrofit intervention on a high density housing building. Different strategies have been explored and the payback periods have been compared.

Keywords:
Energy savings, renewal process, architectural addition, payback time, cost/effectiveness

1 STARTING POSITION AND METHODOLOGICAL APPROACH

The goal of a drastic reduction in energy consumption in the building sector has led to ever increasing attention being paid to the existing stock erected between the ’60s and ’90s, covering over 65% of the urban fabric of several European cities [1].

This stock is affected by relevant technological obsolescence (both physiological and functional) and by a very high level of energy consumption (130-180 kWh/m^2 y). Furthermore, great part of these buildings have turned out to be inadequate in meeting the evolution in family needs and lifestyle.

The methodological approach, proposed by the Research Unit of the University of Bologna, is focused on a step by step retrofit strategy, to be tested on several case studies, with the aim to reduce energy demand to 25 kWh/m^{2}y. This performance level has been assumed as the target of the retrofit action which has been developed assessing the effectiveness of the different technological solution adopted.

Several case studies, located in the principal Italian and European cities, were considered in order to obtain an index of the original construction techniques adopted and a diagnostic analysis of the main pathologies and damages occurred. The prevalent typology adopted in Italian cities is the one based on a concrete skeleton (often exposed in the facade formal partition) with brick blocks closures, but frequent example of pre-casted and on site concrete panel systems are available.

In order to test the performances of several technological solution, aimed at a remarkable decreasing of energy consumption demand after a retrofit action, a simulation model has been set up defining specific deficit and performance lack to be assumed as the starting position for the further steps of the analysis. In this way, different solutions can be compared (starting from the same conditions and aiming at the same performance level) and specific topics can be evaluated.

Starting conditions was set as follows: the bearing structure is a reinforced concrete skeleton made of 25 x 25 cm pillars with a distance of 4 meters (which can be considered the facade module) and of lightweight concrete slabs with a thickness of 20 cm with edge and internal reinforced concrete beams. It is assumed the building is composed of seven level including the ground floor; each floor is 10 meters in depth and 2.70 m in height. Part of the floor slab are extended outside the edge beam in order to obtain the structural support for the terraces. Railings are made of pre-casted concrete panels.

The vertical closure (between the concrete pillars) is assumed to be for 1/2 in a double wall of brick block with different thickness plastered on both sided. The thermal insulation is provided by a polystyrene panel of 3 cm thick in between the two block lines. The other 1/2 of the module is a clear wall from ceiling to floor. The windows are assumed to be in aluminium (single glass layer and devoid of a thermal break). The overall estimated thermal transmittance coefficient of 5.25 W/m^{2}K is well above the limit values set by low. Doors and windows, even when dealing with very large surfaces, have no protection from solar radiation. The roof slab is insulated with a concrete cell of 12 cm, protected by a waterproof membrane and a top coat of metal sheet.

The heating system is assumed to be replaced with a new one in order to provide a more efficient behaviour and to avoid dispersion deriving from a not insulated distribution system.

Even though many differences may occur, most of the typological, technological and construction experiments that characterized the recent history of Italian building sector can be recognized in this model. The model allows to test different arrangements for residential unit between 45-60-90 m^2 which are the typical measurements considering the construction period.

After the starting conditions were set and the primary energy demand was defined in 160 kWh/m^2y (134 kWh/m^2y for heating and 26 kWh/m^2y for hot water production), a compared methodological approach was developed in order to assess the effectiveness of different retrofit strategies

The main goals of the regeneration interventions are: the improvement of energy efficiency, the increasing of the functionality and usability performances of the building, the optimization of the assortment of the dwellings in order to meet the emerging demand trends and finally the new characterization of the building envelope.

In this first phase of the research two different solutions have been compared: a first one involving 100% of the existing building envelope (insulation and replacement of windows); a second one considering 50% of the building envelope completely replaced by new additions and the remaining 50% modified as the first option foresees.

Each technological solution was selected and tested performing an energy assessment, evaluating the thermal transmittance and the index of thermal performance (which has to meet the range provided by law) and then several options were evaluated in order to provide an analysis in term of costs and savings. Energy demand reductions and the effects of integration of devices for renewable energy sources have been assessed.

Two different scenarios were finally explored and tested assuming as primary goal an EP index value equal to 25 kWh/m^2y.

In the current downturn of the market, the design activity should be carried out by taking into consideration initial costs and running costs of the different strategies. The energy and financial aspects are connected each other: a high energy performance solution usually needs higher investment costs, but savings during the life cycle are enough to repay the amount invested at the early stage (figure1).

Consequently, possible solutions are analyzed taking into consideration the savings generated in the long term, while striving to produce results of easy comparison and comprehension, highlighting the economical sustainability of the intervention, with reference to an expected period of time.

Figure 1. An example of high performance addition on existing building.

2 SCENARIOS OF INTERVENTION

The main effects expected by the retrofitting action deal with two different goals: on one hand the need to reduce running energy demand in order to obtain a more sustainable behaviour of the building and a drastic decrease of cost for operating, on the other hand the need to adequate the dwelling asset and dimension to the new trends of demand (two person or families – mostly immigrants - of five and more people, in spite of the middle size flats that represent more than half of the offer) [2]. In order to reach significant results in terms of energy performance level it is necessary to implement the building envelope considering the cost (energetic and economic) needed to realize the intervention. For this reason several options have been evaluated looking for the best ones in terms of indoor comfort/savings ratio.

While the increasing of the performance of the building envelope can be reached without modifying the original asset of the building, a re-arrangement of the dwellings is often possible only introducing some changing like lodges, greenhouses, additions. This elements are also strictly connected with the regeneration effects in terms of relation with surroundings and in terms of functional mix. The introduction of basement addition and satellites volumes on the ground floor area can be a tool to feed a financial mechanism able to generate resources to be used for the building retrofitting (as a matter of fact it is very hard to base the intervention feasibility only on the property investment capacity) [3].

The proposed methodology allows to calculate the costs of the possible solutions, by comparing them with the current status of the model set, which is characterized by very high values of thermal transmittance of walls and windows, with a primary energy demand assumed in 160 kWh/m^2y (which is the average value of the Italian existing building stock).

Two different scenarios were set up simulating the effects in terms of transformation and energy behaviour improvement.

A simulation model has been set up in order to perform thermal analysis and economic evaluation. The model considers a single facade module for the entire height of the building.

The scenarios have been tested considering the climate condition referred to the average values of the cities of north Italy. High performance insulation solutions are needed in winter time, while a more complex behaviour is required during summer time when the principal aim is to reduce the heating deriving from solar radiation.

The two scenarios can be described as follows.

2.1 Scenario A

The intervention mainly envolves the building envelope in order to increase the thermal performance and to avoid dispersion.

It consists in the application of a thermal insulation layer enveloping the building, so that the opaque horizontal and vertical closures reach a thermal transmittance value approximately equal to 0,28 W/m^2K, and in the replacement of existing windows with new wooden ones with double-glazing. Their transmittance is equal to 1.5 W/m^2K (the limit by low is 2.2 W/m^2K). The refurbishment action also provides the installation of solar panels for the production of hot water in order to reach a final EP index value equal to 25 kWh/m^2y which is the threshold appointed as expected result.

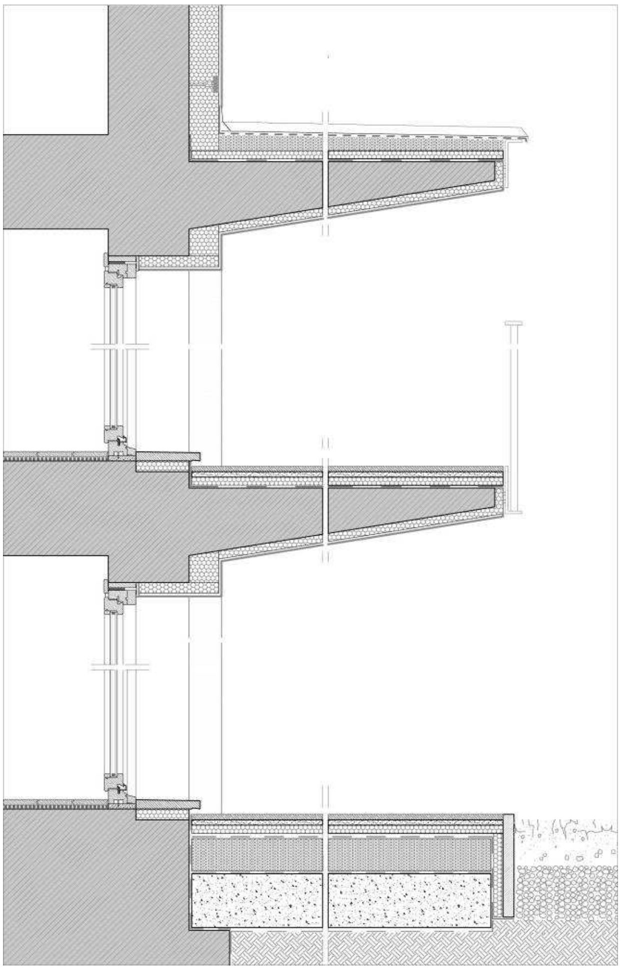


Figure 2. Cross section of the building envelope after interventions following scenario A. The insulating layer has a plastered finishing. New insulated coverings are provided on the windows frames. A double-glazing wooden windows replace the existing ones.

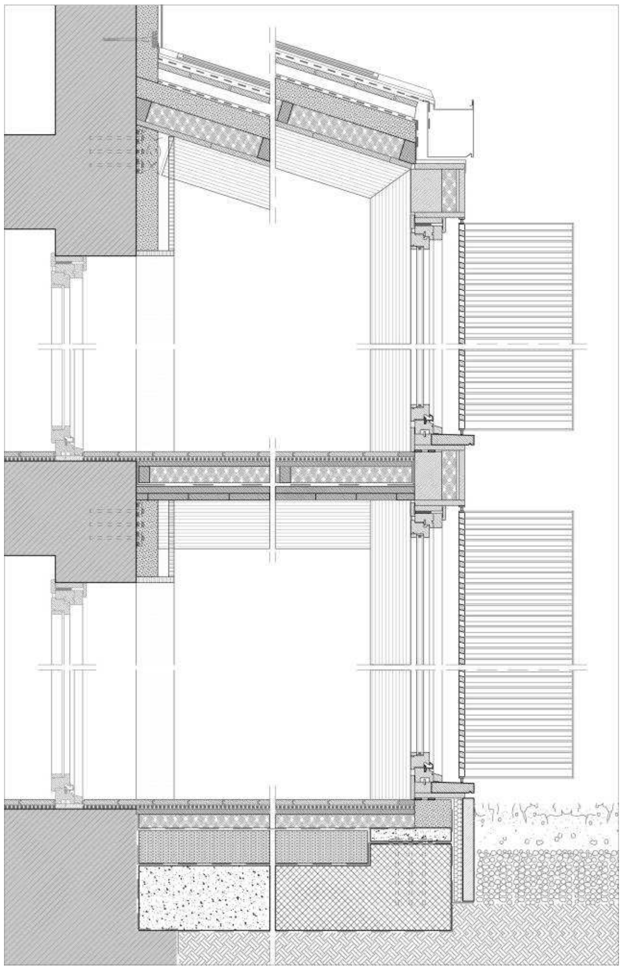


Figure 3. Cross section of the building envelope after interventions following scenario B. The main structure is a wooden skeleton, the side elements of the addition consist of pre-assembled insulated panels and the main facade is a double-glazing wall shaded by a wooden brise-soleil.

Two important factors have to be remarked. The insulation coating have to envelope also the cantilevered slab of terraces (on all the faces) in order to avoid the thermal bridges – as a thermal cut is considered too complex and expensive to be obtained. The sill and the frame of the windows and the doors of the faced module have to be completely insulated in order to support the high performance offered by the new glazing system.

2.2 Scenario B

The intervention is based on the solutions foreseen in the Scenario A for the 50% of the facade (the one including only the opaque closures), while for the other 50% a volumetric addition is provided. So the first two meters width (including a simple window per floor) of the façade module are eneveloped vith the insulating coating for the entire hight of the building, while the other two meteres are interested by the addition development.

The terraces are replaced by new lodges 2 meters width and 2 meters in depth (instead of the 1,2 meters of the terraces) which are thought as an extension of the living space on one side of the building and as an additional space for a room on the other.

The addition is developed from the ground floor to the roof and is provided of a new wooden structure: a skeleton of edge beams and pillars which define the addition facade and support the new wooden deck.

The new structure is connected to the existing building by steel joints. The choice of using a wood structure is connected with the management of the construction time and process. The main wood structure is built on site, while the decks and the side closures are pre-assembled elements to be completed on site. The main facade is a double-glazing window which can be completely open in order to provide natural ventilation and work as a thermal buffer during the summer.

The window is shaded by a wooden brise-soleil which reduces the effects of solar radiation during summer. During winter period the addition provides solar gain which reduces the energy demand for heating.

For what concerns the opaque closures the addition reaches thermal transmittance values approximately equal to 0,25 W/m^2K, and the new double-glazing transmittance is equal to 1.5 W/m^2K. The existing windows can be mantained or removed in according to the new functional layout.

The primary aim of the addition is to obtain a buffer element which offer a good thermal behaviour in variable climate conditions in order to reduce primary energy demand. The refurbishment action also provides the installation of solar panels for the production of hot water in order to reach a final EP index value equal to 20 kWh/m^2y.

3 FINANCIAL IMPLICATIONS AND PAYBACK PERIODS EVALUATION

Even if a volumetric addition seems to be much more expensive than a building envelope implementation, the examined scenarios are quite similar in terms of economic impact. In fact, for what concerns insulating materials and coatings there is an increasing of only 18% in the scenario B (which is less than expected in relation to the need of enveloping the terrace slab which have to be provided by scenario A). There is, of course, an additional cost for the new structure, but the choice of using wood elements decreases costs (in economical terms and also in terms of energy investments).

For what concerns the glazing the two scenario are equal expect for the cost of the shading system of scenario B which represents the minor cost of the windows system.

In the field of financial analysis concerning energy efficiency design solutions – especially in retrofitting and regeneration processes – several indicators of performance (emissions removal, reduction in pollutions, health impact, etc.) are included without considering simply the monetary implications in the evaluation criteria.

This approach is usually known as cost effectiveness analysis. In order to perform this kind of evaluation a time horizon or the period of analysis has to be define: in this case a period of 30 years has been considered.

The investment feasibility calculation is typically carried out using Discounted Cash Flow [DCF] where all the present and future inflows and outflows are discounted to obtain the Net Present Value (NPV), the Internal Rate of Return (IRR) or the discounted payback period (DPBP).

Interventions	U walls (W/m^2K)*	U windows (W/m^2K)	Primary energy needs for heating (kWh/ m^2y)	Primary energy needs for hot water production (kWh/ m^2y)	Primary energy needs (kWh/m^2y)
Starting status	Vertical opaque closures Vertical glazed closures Horizontal opaque closures	5.25	134	26	160
Scenario A	Vertical opaque closures Vertical glazed closures Horizontal opaque closures Solar panels	1.5	17	8	25
Scenario B	Vertical opaque closures Vertical glazed closures Horizontal opaque closures Volumetric additions Solar panels	1.5	12	8	20

Table 1. Data related to each scenario of intervention

The discounted payback period of a project is the time necessary to recover the cost of investment. The cash flows are added up after taking account of the time value of money. The decision is based on comparing the different payback periods with a predetermined cut off period appointed by the decision maker. In order to undertake the economic analysis, all the critical variables have to be correctly identified and appropriate values, based on the current market trend analysis, have to be defined.

It has to be remarked that several point of views can be assumed as starting point in according to the goals of each kind of investors, so a specific evaluation has to be developed for each project. An analysis of several cases run in last ten years shows that projects with a 15-20 years payback time have to be preferred, but of course this is not a market rule. NPV, IRR or payback time period can vary in relation with the effectiveness criteria the evaluation is based on [4].

The economic analysis performed includes the initial costs and the energy investment of each solution as well as the energy savings reached in the expected lifespan. In order to perform each scenario on the entire volume of the building – considering the average dimension of the same typology in the existing building stock – the facade module have been replicated till an adequate simulation model has been obtained. Scenario A and B require an investment of 4.950.500 € and 5.790.400 € respectively. The performance level obtained by each solution is synthesized in table 1.

For what concerns annual management and maintenance cost (which have been accurately described setting up the calculation models) it is expected a growth of 3.3% per year (in relation to the Italian trend) while the discount rate has been assumed at 5%. Table 2 shows the amount of savings achieved by each scenario, both in total value (€) and in reference to the gross floor area of dwellings (€/m^2).

The calculation model takes into account the forecast trend in inflation to 7% for factors related to energy supplies and energy costs, defined by the Electricity and Gas. The return time and the total savings are calculated for a reference period of 30 years.

	Discounted payback time period (year)	Payback time period (year)	VAN	Savings (€)	Savings (€/m^2)
Scenario A	12	10	10 .203.335	15. 202 .957	314,37
Scenario B	13	10	11.934.430	17. 782.286	367,70

Table 2. Return time and cost savings generated by each scenario

4 COMMENTS ON THE RESULTS

After performing the economic evaluation for each scenario, it is possible to compare the different solutions on the basis of the payback period: scenario A seems to be the best choice from a financial point of view as its payback period is 12 years.

In scenario B, the choice of introducing additions for the 50% of the facade entails higher construction costs which impact on the payback time.

If benefits and limits are considered from a wider perspective – which is not simply economic – the scenario B offers the best results: the payback period is very narrow to the best one, and the behaviour and the quality of the building are significantly increased.

The introduction of the volumetric addition simplifies the interventions for insulating the facade and gives a very relevant contribution in term of thermal buffer behaviour in the winter period as well as in the summer.

Furthermore the installation of high performances solar panels helps to reach the amount of savings during the life-cycle and to upgrade the energy performances of the building [5].

A feasibility analysis including economic evaluation (based on multicriteria approach and including quality and energy issues) seems to be an unavoidable step in the development of any effective and conscious retrofit action. Among the relevant limitations related with interventions on the existing building stock the reduction of operating, management and maintenance costs is a very important topic.

The cost/benefit ratio evaluation is an essential tool in order to address the design phase towards the most effective solution. Therefore sharing the decisional process with the end-users for what concerns the management activities, the functional features and the ordinary use can be a strategic factor to define effective solution.

The evaluation process can also support the choice of the construction methods and of the technological solutions. Retrofit interventions are often very complex projects which require, according to the building conception and features, architectural, technological, economical and energetic assessments, managed by a wide design team composed of experts in different fields [6].

From a methodological point of view, the experience tested in the simulation model allowed to point out some fundamental step in approaching to retrofit actions. The arrangement of functional program, the asset of typologies and the possible construction system to be adopted have to be managed following a flexible design in order to adapt them to the results of the financial evaluation performed and to ensure a successful initiative in terms of economic investment, quality improvement, energy savings requirements, environmental standards, etc.

The choice and the priority order of the interventions play an essential role in defining the design strategy in according to the goals to be achieved: the building envelope implementation as well as the introduction of volumetric addition are key factor in facing the request of energy savings performances and of options aimed to climate control [7].

While additions and insulating cladding are necessary to be included in the regeneration program (for the thermal implication described), basement addition, ground floor utilities, connections and non-usable under-roof areas can be involved or not in relation to the level of functional transformation is desired. Another related factor to be considered during the design phase is the ratio S/V of the solution proposed – where S is the surface that surrounds the heated volume and V is the gross volume of the heated parts of the building defined by the surrounding surfaces [8].

Figure 4. An example of compromised building envelope with several heat losses and negative thermal behaviour.

Even if the main goals of the refurbishment are the improvement of the indoor comfort and the upgrade of the energy performance – which is obtained controlling the heat exchange between inside and outside the building envelope – the economic impact of the initial investment deriving by each action is still one of the first choice criteria for investors. For this reason it is very important to remark the opportunities related to the savings and the payback periods of each scenario.

A strategic step in the design phase is to analyze the obsolescence level of the existing building and to outline the main causes of heat losses in order to tackle the problem with the more suitable and economic sustainable solution (cfr. Figure 4). Despite partial interventions are usually cheaper, extensive intervention offer a more balanced relation between the advantages in terms of environmental conditions obtained and economic costs spread in the predicted lifespan (cfr. Figure 5).

Furthermore it is necessary to underline that any economic evaluation is based on a starting position in which the variations of the involved parameters are predicted or appointed, but some random events (economic crisis, speculations, great social events, etc.) can produce an alteration in specific market trends. So it is important to constantly maintain an overall control of the issues involved to ensure an actual effectiveness to the interventions.

Figure 5. An example of retrofit action involving al the main facade of the building.

5 CONCLUSIONS

The paper offers a synthesis of a research work concerning a compared study of retrofit solutions to be tested on a simulation model. A step by step strategy has been adopted in order to analyze the implications in terms of energy performance improvement, while an economic analysis performed through the DCF approach has been used in order to evaluate the economic feasibility of each intervention. The simulations run during the research demonstrated the efficiency of the assessment approach even if the results are still affected by a certain degree of uncertainty due to the difficulties in predicting costs, trends of energy costs, tax relief policies, financial aspects. Nevertheless the cost effective approach adopted is essential to support a suitable decisional process in order to address the design phase to take sustainable (both economically as well as environmental friendly) choices considering the impacts in a medium-long period. A lifespan prediction is therefore necessary for performing the evaluation process and also to consider the economic consequences in terms of maintenance and management and in terms of consumption for the end-users.

The obtained results and the adaptable character of the methodology proposed encourage to deepen the aspects concerning the evaluation of the economic impacts in relation to the initial energy investment which seems to be an interesting challenge for the very next future.

6 REFERENCES

[1] Jørgensen, OB., 2001, Flexren, flexible façade system for energy conscious renovation of European houses. In *Northsun 2001 Technology meets market in the solar age Proceedings*, Leiden.

[2] Di Giulio, R. (edited by), 2010, Improving the quality of suburban building stock, Faculty for the built environment, University of Malta, Malta.

[3] Gaspari, J., 2012, Architectural and technological additions as strategies to improve urban quality in refurbishment actions. In Di Giulio, R. (edited by), *Improving the quality of suburban building stock*, Unifepress, Ferrara.

[4] Brown, G., Matysiak, G., 2000. *Real estate investment, a capital market approach*, FT: Prentice Hall, London.

[5] Boeri, A., Longo, D., 2010. Eco-technologies for energy efficient buildings in Italy. In Hernandez, S., Brebbia C.A. & De Wilde W.P. (edited by), *ECO-Architecture III-Harmonisation Between Architecture and Nature*, WIT Press, Southampton.

[6] Cofaigh, E.-O., Lewis, O.-J., Olley, J.-A., 1996, *The climatic dwelling: an introduction to climate-responsive residential architecture*, James & Jame, London.

[7] Sassi, P., 2006, *Strategies for sustainable architecture*, Taylor & Francis, New York.

[8] Herzog, T., 1996, Solar energy in architecture and urban planning, Prestel, Munich-New York.

Bioclimatic Planning and Innovative Skin Planting Technologies for the realization of Nearly Zero Energy Buildings: a Case Study

M. Caini[1], R. Paparella[1]
[1] Department of Civil, Environmental and Architectural engineering,
University of Padua, Padua, Italy

Abstract

With the directive 2010/31/CE, the European Union imposes to its country members from the beginning of 2020, the objective of realizing buildings at zero energetic consumption. Through the analysis of a Case Study, this work shows how it is possible to reach such an objective through the combination of two fundamental factors: the use of a specific planning methodology and the appropriate use of technologies containing integrated and innovative plant designed systems. The adopted planning methodology develops and verifies the principles of the bioclimatic planning through the aid of computerized modelling and it follows a precise procedure developed by steps. The objective of this planning method is that to exploit in an optimal way the contributions of the climatic elements present in nature and to integrate the residual part, resorting to the use of integrated skin.

Keywords:
Sustainability, Environmental Planning, Bio-climatic design, Domotic, Solar Cooling

1 INTRODUCTION

In accordance with the principles of bioclimatic design, the work aims at using in an optimal way the characteristics of the external environment in order to achieve the well-being in the built environment. The aim is to achieve the following objectives: to minimize the environmental impact, to use existing climate resources, to reduce energy consumption, to improve the levels of sustainable development, to improve the health and well-being of the people living and working in that specific environment, to realize buildings at zero energy consumption and at zero CO_2 emission.

On a building scale, the case study shows how it is possible to implement strategies which are able to maximize the use of the area's climate resources and to meet the energy demand through a bio-climatic analysis of the site, for example for the conditioning or for the use of domestic appliances and lighting, through the use of advanced technologies such as solar cooling and the photovoltaic system.

In this way, the objective of being able to realize buildings at zero energy consumption can be met.

The design was carried out using the software Design Builder. It allowed to perform simulations of the indoor microclimate and consequently to quantify the residual energy demand not directly satisfied by the climatic conditions of the site.

This was useful to design the "solar cooling" plant consisting of panels integrated with the skin and the absorber machine installed on the roof, able to fully meet the remaining requirements of cooling and air conditioning of the buildings.

Finally, it was possible to quantify the amount of electricity needed to power the little requirements of the absorber machine, the appliances and the lighting.

With the use of specific software, the adopted planning methodology develops and verifies the principles of the bioclimatic planning through the aid of computerized modelling and it follows a precise procedure developed by steps, such as:

• the monitoring, the gather and the execution of the systematized analysis of climatic data retrieved on site in the last five years;

• the construction of the standard climatic year and the insertion of such datum in the bioclimatic diagram;

• the necessary climatic corrections in order to bring the constructed environment inside the comfort conditions directing the choices for the following step;

• the development with iterative method of the real architectural planning.

The bioclimatic design methodology carried out in an iterative way according to precise steps explained below and the complementary use of the software have played a key role in obtaining the correct answers in relation to the orientation and the relations between shape and volume, the relations in facade between opaque and transparent surface for the individual building, as well as for several buildings such as the mutual positioning.

This is a crucial factor due to the fact that the energy subsidy provided by the plants was contained and therefore feasible for size and costs.

2 THE CASE STUDY

The experimental design presented below deals with the issue of the residence. The program involves the design of residential terraced buildings.

The climatic and environmental context of reference is that in the southern hemisphere near the lagoon of Porto Alegre in Brazil.

The project site overlooks Lake Guaiba. The area is characterized by sub-tropical climate with hot and humid summers and mild winters. The summer temperatures reach about 30 ° C with a high rate of relative humidity that can reach 95%, winter temperatures vary from about 10 ° C to 17 ° C with a daily range of 10 ° C.

The methodology involves at the first step:

a) The analysis of structural invariants of anthropogenic valence (historical analysis and possible archaeological analysis);

b) The analysis of the infrastructural invariants (roads, specialized nodes and local specialized equipment).

c) The analysis of structural invariants of natural valence (hydrological and geomorphological analysis).

The second step involves the analysis of the physical characteristics of the territory. To do this it is necessary to make use of climate data gathered from a meteorological monitoring station near the site. Data were collected from the last five years in relation to Wind speed (m / s), wind direction (degrees), dry bulb air temperature (° C), relative humidity (%), direct solar radiation and diffuse solar radiation (Fig.1).

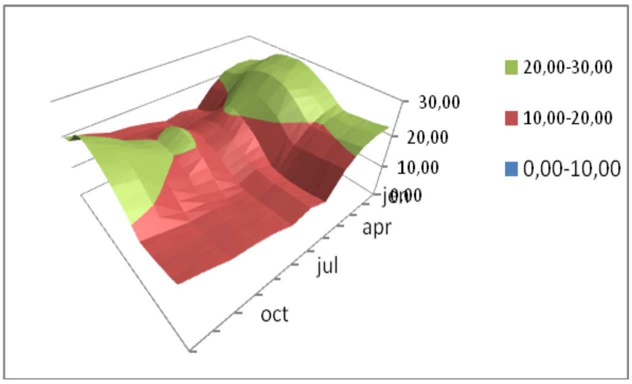


Figure 1: dry bulb air temperature and relative humidity

The third step involves the construction of the standard climatic year. The climatic data were analyzed and systematized so as to obtain the standard climatic year.

In particular, for the wind it was possible to determine the monthly averages, the standard day for each month with a summary of the parameters of direction and intensity during the overheated period.

It was seen that the exploitation of the wind resource for the purposes of and indoor natural ventilation using the known principles of activation such as the cross ventilation and the stuck ventilation, contributes to approximately 60% of the Energy Saving for summer air conditioning [**1**].

From the analysis of the graphs on the dominant directions of the winds it can be noticed that the two main directions are respectively north and south-east (Fig. 2).

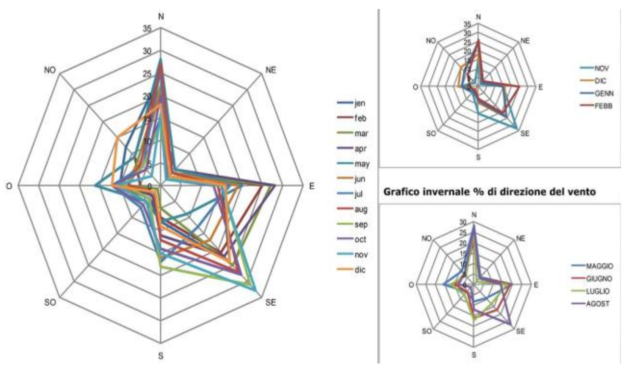


Figure 2: Direction intensity and frequency of the wind resource illustrated by month.

During the summer period, which is of most interest for the exploitation of natural ventilation the average wind speed is equal to 3 m / s; this is an optimal condition for the achievement of the objective previously stated.

Always crucial for the achievement of the objective is the presence of the lake nearby the project area; this presence favours the breezes phenomenon (Fig.3).

Figure 3 Site plan with the direction of the prevailing winds.

The analysis of the solar radiation during different periods of the year shows that in summer, the main direction is east-west with a value of 3500W/m^2 on vertical surface and 9000W/m^2 on horizontal surface, in spring and autumn the main direction is west north-east with a value of 3000 W/m² on vertical surface and 6700 W/m^2 on horizontal surface, in winter the main direction is north with a value of 3400 W/m² on vertical surface and 4600 W/m^2 on horizontal surface.

From this the following considerations can be drawn:

• The optimum orientation is North;

• It is necessary to consider a reduction of exposure in direction east-west;

• Very isolated roofs must be designed and skylights must be avoided in the architectural design;

• Finally, it should be noted that the site is appropriate for the use of photovoltaic technology.

The fourth step involves the representation of climatic data systematized within the bioclimatic chart for the area concerned.

In this case, reference is made to the Olgyay psychrometric chart (Fig. 4) in tribute to whom in the 60s of the last century laid the foundations of bioclimatic design.

However, other psychometric diagrams could be used such as the one developed by Givoni and updated on the diagram ASHRAE.

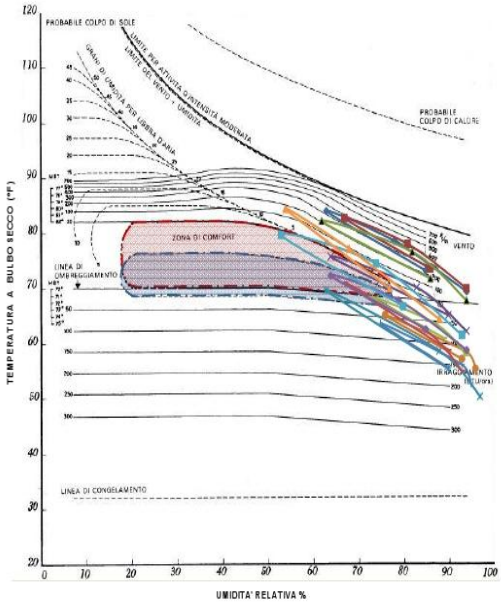


Figure 4: Olgyay diagram for the case study.

This diagram identifies the area of comfort for the conditions of relative humidity and temperature on site, this allows the designer to understand the extent to which the climatic conditions of the site are within the comfort area.

During the periods of the year when these do not fall within the comfort area, it is necessary to implement design strategies that can guarantee comfort. On one side, these strategies are of the passive type, on the other hand they appeal to the plant subsidy. The area circumscribed represents the comfort zone.

The fifth step is to identify the climatic requirements and their integration with the actual availability on site of the climatic element. From this analysis, it appeared that to meet the comfort conditions of the diagram in (Fig. 4), it is necessary to supplement the air conditioning in summer. For this purpose we used the plant system solar cooling.

Based on the analysis carried out, the sixth step is to develop the first project idea with the implementation of appropriate strategies (Fig. 5) primarily aimed at the maximum exploitation of the analyzed climate resources quantified in the previous steps, in relation to orientation, to the relations between shape and volume, to the relations in facade between opaque and transparent surface for the individual building, as well as for several buildings such as the mutual positioning.

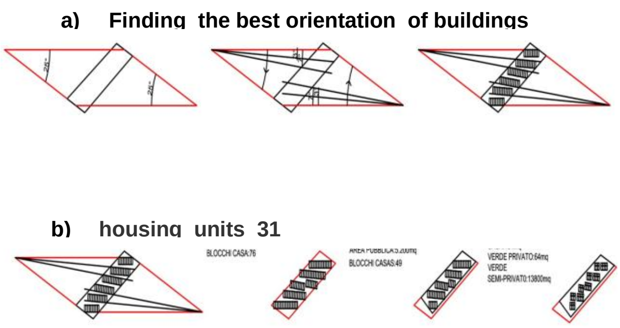


Figure 5a-5b: Concept design with orientation of buildings in accordance with the climatic data

Figure 6: General plan of the project

The architectural design choices are then analyzed and controlled in the seventh step with the aid of the software of physical-technical modelling, in this case Design Builder.

In this phase the technological choices of the skin are perfected as shown in Fig.7 in which it can be seen how the closure package is composed of the laminated wood structure x-lam 15 cm, a thermal insulating layer made of wooden fibre 6cm, of a ventilated wall with ventilation chamber equal to 5cm and a coating layer of wood.

The transparent closings are with Uw of 0.95 W / mqk.

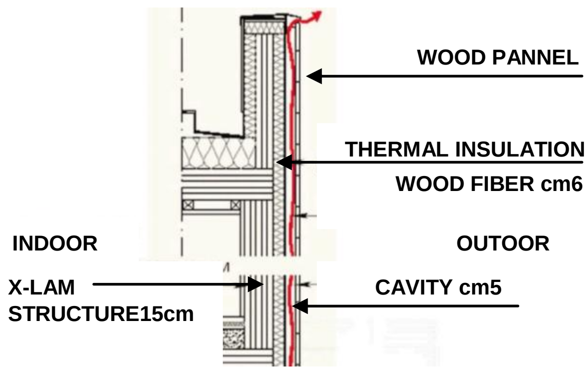


Figure 7: Detail of the exterior wall system

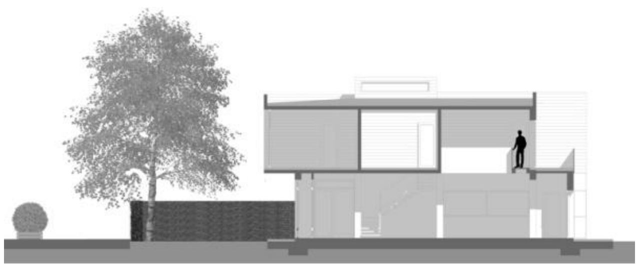


Figure 8a: section showing the front of the building that needs special shading

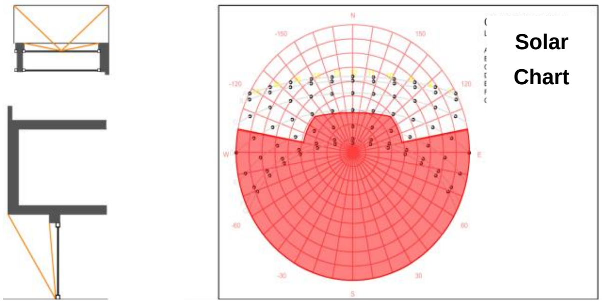


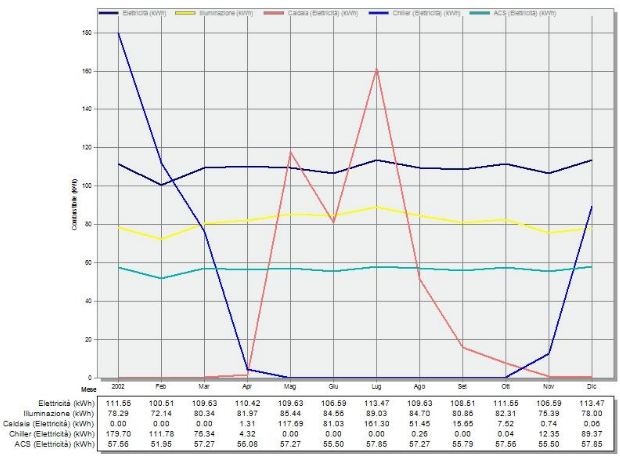
Figure 8b: Study of the projection's shadings, for the glazing parts of the building

A key role in achieving zero energy consumption is given by the study of shade and the shields. As a matter of fact, it is shown that the use of mobile domotized screenings allow an energy saving equal to 43% [**2**].

In the present case study, the projections have been designed using the solar card for the control of the shadings (fig.8 a-b) and domotized shielding have been evaluated.

The total annual consumption of electricity per unit is equal to **3.772,92**Kw. This consumption is respectively: 1311,54 Kwh for domestic appliances, 973,01Kwh for lighting, 436,75 Kwh for heating, 474,17 Kwh for cooling, 577,45 Kwh for domestic hot water (fig.9a-b).

a) Energy consumption for month (1 jan-31dec.)



b) Energy consumption (1 jan-31dec.)

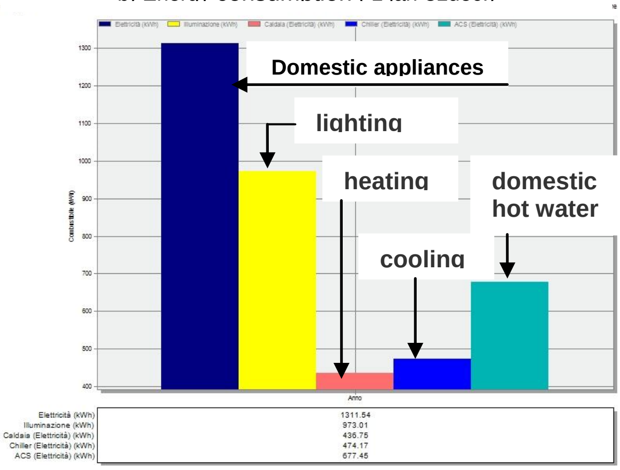


Figure 9a-9b: Diagrams of the annual consumption of electricity for accommodation

For the fulfilment of such requirement it is evaluated the installation of a photovoltaic system integrated in cover, occupying an area of 36 square meters, with power equal to **4**kWp, capable of producing in a year **5153** Kw and thus of ensuring full coverage of the energy requirements of each individual accommodation respectively: for lighting, for heating of the sanitary water, for use with appliances and to feed the absorption machine of the air conditioning "solar cooling" (Fig, 10).

Figure 10: Position of the panels of the solar cooling system in the facade.

This system takes advantage of the solar radiation intercepted by eight panels of dimensions equal to 102.9 cm x 195.9 cm integrated into the building's skin, which collect the solar radiation required to operate the thermodynamic cycle of the absorption machine which is placed in cover on the technical compartment in correspondence of the stairwell (Fig, 10 and 11a-b). It is capable of producing a cooling capacity of 3.27 kW and uses lithium bromide as the absorbent liquid.

The eighth step involves iterative method with the refinement of the project to achieve the objectives.

Figure 11a: Position of the panels of the solar cooling system in front.

POSITION OF ABSORPTION MACHINE

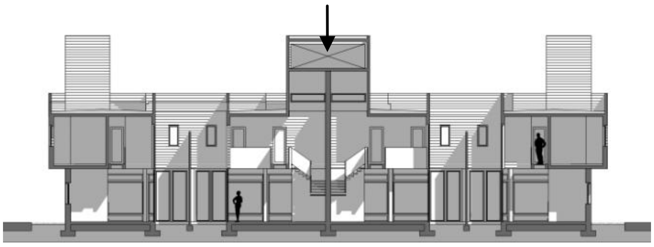


Figure 11b: Position of the absorption machine of the solar cooling system in front.

3 CONCLUSIONS

The study carried out, gives general guidelines that apply to a method of bioclimatic design through specific operational steps that, in an iterative way, allow to conceive the best architectural solutions and to adopt the most appropriate technological solutions aimed at the realization of zero energy buildings in the subtropical band of the southern hemisphere.

It appears that in climates with high humidity and with a prevalence of warm periods and alternating mild periods, the optimization of the usage of energy resources still requires interaction between building and environment.

As a matter of fact, the optimum is reached by the minimization of solar gains in the overheated period and in allowing, in the cold period, the entering of the greatest amount of solar radiation as possible.

This is achieved by integrating the energy deficit with innovative engineering solutions.

The use of the photovoltaic system reduced in size and power installed with the aim of producing electrical energy and the cooling system solar cooling which exploits the principle of absorption, appear to be mature technological solutions that allow to achieve the established objectives.

Finally, the study carried out shows how the methodology of bioclimatic modelling assisted by software of physical-technical modelling is also an indispensable and essential tool for the achievement of the objectives.

4 REFERENCES

[1] Caini, M., Paparella, R., 2012, "Design Strategies For Optimizing Natural Ventilation In The Mediterranean Area: Case Studies Analysis." IAHS XXXVIII World Congress on Housing in Istanbul (Turkey) from pag. 684-692. ISBN : 978-975-561-418-2

[2] Caini, M., Paparella, R., 2012, "Design Methodologies To Construct Sustainable Buildings, In The Mediterranean Area, Based On The Use Of Renewable Resources Integrated With The Use Of Intelligent Systems". 4th SASBE 2012 International Conference on Smart and Sustainable Built Environments in S. Paulo (Brazil) from pag.125-135 ISBN: 978-85-65823-05-0

[3] Ascenzi, G., Villi, G., Vulpiani ,G., Guida all'utilizzo di FDS. La modellazione automatica degli scenari d'incendio, Ed. Dario Flaccovio

[4] Awbi, H.B., 1991, Ventilations of buildings, Chapman and hall, London.

[5] Bahadori, M.N., 1978, Passive Cooling Systems in Iranian Architecture, Scientific American Vol. 238 N°2 February , New York.

[6] Bottema, M., 1993, Wind Climate and Urban Geometry, TU Eindhoven (NL).

[7] Brown, W., Dekay, M. , 2004, Sun Wind and Light, McGraw Hill, New York .

[8] De Santoli, L., Mariotti, M. , 2011, La ventilazione naturale: il moto naturale dell'aria per il controllo delle condizioni ambientali, Dario Flaccovio Editore, Palermo.

[9] Ethedrige. D.. 1996 Building Ventilation: Theory and Measurement, , Jhon Wilery and Sons Chichester.

[10] Olgyay, V. Design with Climate, Bioclimatic approach to Architectural Regionalism, P.U. Press.

Specific Aspects of Sustainability in the Design of Hybrid Buildings

M. Burazor[1]
[1]University of Sarajevo, Faculty of Architecture,
Bosnia and Herzegovina

Abstract
New materials and technical solutions are available that help architects to design more efficient buildings. Use of *smart materials* and implementation of special technical solutions for air-conditioning are some of the specific aspects of sustainability in buildings that are based on hybrid concept. The implications of optimisation in the floor plan have even more influence on total building performance. This potential of reduction based solely on optimization and reduction of floor plan is explored as an important characteristic of green design. In recent years a number of hybrid buildings have achieved highest LEED platinum standards.

Keywords:
Energy efficiency, optimisation, hybrid concept, hybrid efficiency

1 INTRODUCTION

Improvements in technology have always influenced architecture. In terms of design, computer aided design and structural analysis programs have had tremendous impact on the evolution of form in the past 20 years. At the same time, new buildings materials, construction techniques and HVAC systems are available that can help architects to design more energy efficient buildings. This is why it has become so important to find means of measuring performance of the buildings in order to be able to compare and evaluate buildings and come with a conclusion which solutions function more efficiently. It is possible to assess material quality, noise control, fire safety, thermal efficiency, and internal air quality. All these specific aspects in turn affect 'building performance' and traditionally, most research has been done along the lines of analysing and improving building components. However, in order to assess how well a building is behaving overall and in the long term, a more holistic approach is needed as suggested by James Douglas in his research paper on the topic of building performance and its relevance to facilities management.

Total building performance in turn combines several performance indicators such as: durability, space functionality, access, location, quality, flexibility and cost efficiency, code compliance, energy efficiency, restoration costs, change of total staff size, image to outside, telecommunications, fire safety and safety in use [1]. All these individual components can be assessed and in total offer better tool to evaluate sustainability of building as a whole rather than only one aspect such as energy consumption. Main issue to discuss here is what architects can do in terms of design that will make buildings more sustainable and energy efficient. Intention is to show that hybrid concept has its advantages over traditional ideas.

2 HYBRID MATERIALS, PRODUCTS, SYSTEMS AND THEIR RELEVANCE TO BUILDING PERFORMANCE

Use of the word 'hybrid" is wide spread and when it comes to technology it is quite commonly used to describe sophisticated solutions based on mixing different properties to create something new and better. The idea of hybridisation itself originates from biology and genetics in particular and it can even be traced to Aristotle [2]. Pioneers of genetics Joseph Gottlieb Kölreuter and Gregor Mendel set the scientific bases for the interpretation of hybrids [3]. Kölreuter was first to observe and describe hybrid vigour or heterosis within plants and animals and perhaps the most important conclusion that Mendel had made was that hybrids have very important role in the process of evolution [4]. This idea, based on a fact that in a process of cross-breeding offspring exhibit better characteristics than their parents, has influenced technology in many ways. One approach is to mix different materials to create new materials - hybrids that will have better properties than its predecessors.

2.1 Hybrid materials

When describing hybrid materials, term 'smart materials' is frequently used almost as synonym. Those are materials and products that have properties that are subject to reversible change (in terms of shape and colour) when exposed to external influences such as light, temperature, electrical charge or any other physical or chemical stimulant. NASA defines 'smart materials" as materials that are able to 'remember" configurations and adjust to specific stimulants [5]. There are ample examples of these materials that are used now in construction. Thin solar films and organic solar cells are relatively new technical solutions that have found its place in architecture. Beside them, dye solar cells (DSC modules), thermo-electrical generators and systems that are based on piezoelectric properties have also been adopted. Hybrid properties can also be found in derivatives that are produced when combining biological and synthetic components. Currently in the field of architecture lots of research has been done on insulating materials that in combination with others take on extraordinary properties. For instance, there are vacuum insulating panels (VIP) that can already be found in the market or switchable thermal insulation (STI) developed by research centre ZAE Bayern in Germany.

The assumption that physical borders are at the same time spatial borders, has influenced many authors to focus their attention to highly integrated, multifunctional façade systems as well as walls, floors and ceilings. Mike Davies popularised term ‘polyvalent wall’ which he described as a façade that is capable to protect from sun, rain and wind and which has thermal insulation ability and allows for ventilation and pass of natural light [6]. This wall consists of photovoltaic mash, layer of sensors, heating installations, membranes and waterproof skins and has influenced architect to seek and develop new ‘super façades’. Apart from hybrid materials, today we witness application of hybrid ventilation systems, electrical and even hybrid constructions in contemporary buildings that are responsible for highest LEED ratings.

2.2 Hybrid ventilation system

Combining natural and artificial (mechanical) ventilation is one way of achieving energy efficiency in buildings. Natural ventilation is applicable only in certain climatic zones while hybrid system is applicable in more sever climatic conditions. In scientific research paper on topic of *Hybrid ventilation for low energy building design in south China* experiment was conducted that supports theses that hybrid system is more energy efficient than traditional solutions [7]. Using dynamic thermal simulations and data from analysis, authors discovered that hybrid ventilation system has potential to reduce energy consumption by 30-35% when compared to traditional systems. Another advantage was that the quality of air in interior was considerably improved in the period between seasons when building could function as a ‘passive house’. Conducted research was motivated primarily by increasing demand for energy in China and finding new ways to use more efficiently existing capacities. From the economical point of view, implementation costs for these solutions are usually higher than those for traditional systems and this shows that economical aspect sometime comes after ecological concerns.

2.3 Hybrid photovoltaic – thermal collector

Preserving energy and achieving maximum efficiency whilst having minimal energy consumption is a constant pursuit for scientists. When it comes to combining photovoltaic and thermal collector and integrating them into a wall results have shown that thermal efficiency is much higher than for conventional solar collectors [8]. In an attempt to predict thermal and electrical performances for Hybrid PV/T system, authors assumed that façade wall is oriented towards west without any horizontal obstacles. They also assumed that internal temperature is constant for the period of cooling and all relevant input data was evaluated prior to conducting computer simulations. Results have shown that annual electrical efficiency for the treated surface area of $40m^2$ is 4,3% for EPV/T (film cell) and 10,3% for BPV/T (single silicon cell) whilst annual thermal efficiency was 58,9%, and 70,3% respectively. Efficiency of water heating system was 47,6% for EPV and 43,2% for BPV and temperature of the water was 45^0C and more for 195 days for the first system and 217 days for the other. Based on these data, authors concluded that these hybrid systems are applicable for domestic use and compared to a normal concrete wall, reduction of heat gain can be up to 53% and 59,2% respectively for tested systems. These systems are viewed as most desirable method of generating electricity and heating of water.

Both for hybrid ventilations system (where emphasis is on energy preservation) and hybrid photovoltaic – thermal collector (where the goal is to use most of free solar radiation) common ground is optimisation. This idea is appreciable in hybrid constructions too and should be introduced to architectural design.

2.4 Hybrid constructions

Structural engineers have adopted hybrid concept in construction for a long time. One of the recent examples is use of fibre-reinforced polymer which is mostly used in bridge constructions. However, attempts were made to apply FRP-lightweight concrete sandwich system in buildings. Scientific basis for this is provided by Erika Schuman’s experiments where she compared traditional reinforced concrete with hybrid FRP-lightweight concrete constructions [9]. She found out that hybrids have better characteristics in terms of weight reduction, higher strengths and greater freedom in shaping. Another advantage of polymers is that they do not corrode and in that sense last longer than steel rebar. Difference between classical reinforced concrete slab and hybrid slab system is only in materials that are in use. With hybrids, lightweight concretes are used together with FRP and this mix allows them to withstand greater forces. This in turn means that greater spans are possible when applying this type of construction. Drawback is that it costs more than traditional and this is one of the main reasons why they are not more extensively used.

Similar to the way that structural, mechanical and electrical engineers have embraced hybridisation, architects too have found potential in developing new breeds of buildings.

3 HYBRID BUILDINGS

It turns out that there is no single definition of hybrid buildings. For some architects ‘cargotecture’ is a result of hybrid architecture and assembled construction system [10]. According to the authors this is hybrid because shipping containers are being used as building blocks and for something that they were not originally intended. Certain advantage is that these buildings can be moved from one site to another and construction time is drastically reduced when compared to traditional buildings. Although these structures share same idea of mobility with camping vans, there are quite a few differences. When it comes to movability, camping vans are more practical to use but main advantage of cargotecture is modularity and ability to grow in size. This means that depending on architectural and interior requirements, it is possible to increase space vertically and horizontally. Also, it is possible to create custom openings in outer walls which increases adaptability and diversity which makes it more flexible than camping vans.

One of the definitions of hybrid buildings is strongly influenced by mechanical and electrical solutions.

‘Hybrid buildings are defined here as residential buildings that have the capacity to supply, in total, the annual operating energy requirements of their occupants by utilising locally generated (low or zero emission) energy sources” [11].

One of the first hybrid houses was developed on the presumption that it should not rely on local electrical grid but it should be self-sufficient. Maximum solar exposure on solar cells that charge batteries which are placed in foundations is one way of producing and preserving electricity. Integration of hybrid mechanical ventilation and thermal collectors is proposed solution by some for creating hybrid buildings. This approach however raises question is it justified to model buildings based on maximum solar exposure or heating/ventilation demands? Architects are faced with dilemma when designing buildings where energy efficiency restrains are in collision with desired form. However, there is another definition of hybrid buildings which does not necessarily include hybrid materials, products and technical system but nevertheless offers tools for reducing energy consumption and sustainability.

Until Joseph Fenton's catalogue from 1985, hybrid buildings were ignored as recognizable building structures and they were usually in a category of 'mix-use" buildings [12]. Fenton believes that there is a strong distinction between hybrid buildings and buildings with different uses, because individual architectural programs interact one with another and begin to share intensities [13]. In essence, synergy is main characteristics of hybrids where whole becomes more than just sum of its parts. Combining different programs (thematic or disparate) into single structures is a true interpretation of hybridisation process that originates from biology. Similarly to previously outlined manifestations of hybrids, it is expected that hybrid buildings have better characteristics than their predecessors. Optimisation is also a key feature of hybrids and alternatively to previous definitions, one can state that architectural structure which combines at least two different typologies that as a result have optimisation of floor plan is called hybrid structure. This statement is further explored in order to find out if these types of buildings function better than their classical 'parents".

3.1 Hybrid efficiency

When observed through the prism of architectural program and rationalisation due to reduction of total surface area when two mono-functional programs are combined, this property can be mathematically represented as follows:

$$A_T = A_1+A_2 \ [m^2] \quad (1)$$

Where 'A_1' is surface area of the first typical building and 'A_2' is surface area of the second building. Total surface are is 'A_T' in this case.

$$A_H = k*A_T \ [m^2] \quad (2)$$

Where 'k' is coefficient of optimisation which is <1 for hybrid structures and 'A_H' is total surface area of hybrid building.

Running costs for certain building are good representative of how successful one solution is compared to another. These costs can be examined through following categories: investment cost, maintenance cost, energy consumption, fix fees and employee reimbursements. As long as costs are smaller, proposed solution is better.

Investment

It is axiom that total investment of hybrid building which consists of two mono-functional programs is smaller than combined investment price for two independent mono-functional programs solely based on the fact that total surface area is smaller when combined. It is possible to prove this concept with a simulation where input parameters are same for hybrid building and mono-functional buildings at the same site. This method of modelling is used to create an ideal system where it can be proved that investment cost is smaller based on total surface area reduction due to common spaces.

Energy consumption

When it comes to energy consumption, it is general knowledge that higher energy efficiency i.e. smaller consumption is positive qualification when assessing building performance. If we asses two identical buildings and if one of them uses previously mentioned hybrid installation systems, it will use less energy and therefore it will function more successfully than the other. When we asses hybrid building it is possible to draw conclusion that due to optimisation of floor plan, less energy is used for heating/cooling using the same systems when comparing traditional and hybrid buildings.

Fix fees

In certain parts of the world there are still fix fees for buildings that have to be paid by owners. These fees are calculated on the basis of total surface area and are valid for calculating waste disposal fees, central heating and maintenance costs of building. Although there is a general tendency to charge actual consumption of natural resources and energy, in Bosnia and Herzegovina for instance these costs are still linked to surface area. So when it comes to fix fees, yet again hybrid buildings have advantage when compared to mono-functional buildings because their total surface area is smaller.

Employee reimbursements

Depending on the number of employees, pay checks usually surpass material costs, cost of manufacturing and cost of amortisation of a certain business [14]. Advantage of hybrid concept for management is seen in reduction of total number of employees and hence costs are smaller. This reduction annually add up to 2692£ per employee for office buildings [15]. This statement is based on an assumption that certain departments which exist independently in different buildings (legal department, economical, maintenance and security) can be combined in hybrids thus reducing total number of employees.

Mobility and user satisfaction

Availability of different content in hybrid buildings is better than for typical buildings. This is based on a fact that hybrids integrate different functions within single building or complex. This means that users have to travel less to complete given tasks. In city environment, when one has to use car, advantage of smaller distances is reduced fuel consumption and less noise and air pollution. Also cost for parking is smaller. In general, costs for transport are smaller and from economical point of view, for users it is much more convenient to have several functions combined in one place.

Time efficiency

For many individuals time efficiency becomes priority and it comes even before ecological and financial aspects. Not surprisingly people buy goods which are more expensive than in other places just if it means saving time. In business world, managers speculate with work hours and are seeking ways to improve time efficiency. Furthermore quality of life is directly linked to the amount of free time. Multitasking comes as natural for humans and when fulfilling several tasks at one place rather on several different locations is true time saving. This is yet another advantage of hybrids over traditional buildings.

3.2 Conclusion

Economy plays important role in sustainability of buildings. It is not enough for a building to be energy efficient to be sustainable. Certainly, new technologies have to be adopted in order to maintain rising costs and preserve natural resources. However, true challenge for architects is to create buildings which will be utilitarian and lasting enough to be truly sustainable. Based on the analysis of costs and spatial optimisation repercussions, it is clear that hybrid buildings are superior type of buildings.

4 REFERENCES:

[1] Douglas, J., 1996, *Building performance and its relevance to facilities management*, Facilities, Volume 14, number 3/4, MCB University Press, pp. 23-32

[2] Sturtevant, H.-A., 2001, *A History of Genetics*, Cold Spring Harbor Laboratory Press, New York, p. 2

[3] Fenton, J., 1985, *Pamphlet Architecture 11: Hybrid Buildings*, Library of Congress Catalogue Card No. 82-062717, New York, p. 4

[4] Orel, V., 1996, *Gregor Mendel: The First Geneticist*, Oxford University Press, New York

[5] http://virtualskies.arc.nasa.gov/research/youDecide/smartMaterials.html (23.07.2011.)

[6] Davies, M., 1981, *A wall for all seasons*, RIBA Journal, 88 (2), London, pp. 55. – 57.

[7] Ji, Y., Lomes, K.-J., Cook, M.-J., 2009, *Hybrid ventilation for low energy building design in south China*, Building and Environment 44, pp. 2245. – 2255.

[8] Jie, j, Tin-Tai, C., Wei, H., 2003, *Dynamic performance of hybrid photovoltaic/thermal collector wall in Hong Kong*, Building and Environment 38, 2003., pp. 1327. – 1334.

[9] Schuman, E., 2008, *Hybrid FRP-Lightweight Concrete Sandwich System for Engineering Structures*, Doctorate, ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE, Lausanne, p. 134

[10] http://www.hybridarc.com (23.07.2011.)

[11] Newton, W.-P., 2009, *Hybrid Buildings: Pathways for greenhouse gas mitigation in the housing sector*, Swinburne, Melbourne, p. 19

[12] Fenton, J., 1985, *Pamphlet Architecture 11: Hybrid Buildings*, Library of Congress Catalogue Card No. 82-062717, New York, p. 6

[13] A+T, ed. Fernandez, P.-A., Mozas, J., 2008, *Hybrids I*; *High-rise mixed use buildings*, a+t ediciones, p. 7

[14] http://www.blberza.com/v2/Pages/financialfiguressearch.aspx (06.01.2011.)

[15] Douglas, J., 1996, *Building performance and its relevance to facilities management*, Facilities, Volume 14, number 3/4, MCB University Press, pp. 23-32

Examples of Energy Efficient Architecture in Bosnia and Herzegovina and Macedonia

H. Bradic[1]

[1] Department of Architectural Constructions and Building Technology, Faculty of Architecture in Sarajevo, Bosnia and Herzegovina

Abstract:

This paper aims to provide analysis of the energy efficient architecture by presenting several designs produced by the architect Haris Bradić in Bosnia and Herzegovina and Macedonia. Houses that will be presented in this paper are residential facilities, which are currently under construction, or in the preparation phase of the construction. This short overview of the aforementioned designs will focus on the analysis of energy efficient construction. The paper will also show how specific software can be used from the earliest stage of a design process all the way to the final calculations. Besides the energy calculations, the goal is to provide information on how to build an energy efficient structure in Bosnia and Herzegovina and Macedonia, which procedure is still very difficult for all participants in the project, including investors, designers and constructors. The first example presented here is a reconstruction of an existing, over 400 years old, house in Sarajevo into a passive house. The next example is a newly designed house on the outskirts of Sarajevo – Poljine, Kromolj, which is still under construction; finally, the third structure is a private villa in Macedonia, near Tetovo. The paper next considers the relationship between the designer and investor, who is an important figure in creation of the energy efficient architecture, and also the social circumstances under which a specific design is being produced. The main purpose of this type of architecture is to build a structure with as minimum energy needs as possible that will be secured through alternative sources of energy, and ultimately resulting in a *Zero Emission House.*

Keywords*: Energy efficient architecture, energy, environment, economy, man.*

1. INTRODUCTION

This paper considers the particularities of designing energy efficient residential buildings by presenting three such examples designed by the architect Haris Bradić, which are currently under construction. The referenced houses are located in Sarajevo, Bosnia and Herzegovina, and Senekos, a small village near Gostivar in Macedonia. Climatic data for both geographical areas have been analyzed in terms of minimum and maximum air temperatures *per* year, number of clear days and wind speed. The main purpose of energy efficient building designs is to find ways to use the potential of a specific area, i.e. how to exploit the solar and geothermal energy. In above mentioned examples, borehole drilling was carried out as to obtain results about the geothermal potential of the referenced area. Two computer programs were used for calculation of the annual energy demands: *ENSI software 8.1 BiH and PHPP 2007*, which is primarily used in passive house designs. Final objectives included: to build structures with minimum carbon emissions, or zero carbon emissions, to build structures with minimum energy needs, i.e. not exceeding 50kwh/m^2 *per annum*, to increase the comfort of the interior space in terms of architectural physics, to provide clients with the obtained results regarding the quality of the structure in which they will reside, which is very important because these projects are designs of private houses that are often clients' most important life investments. Finances, i.e. the construction price, are usually an impediment which needs to be overcome by both the client and designer as to define the path to be taken throughout the entire construction process. The biggest obstacle in the aforementioned process is the fact that Bosnia and Herzegovina does not have appropriate regulations on the referenced issues, or institutions to support the energy efficient construction in any way whatsoever.

2. EXAMPLES OF LOW ENERGY HOUSES

The first house presented in this paper is a residential facility located in Sarajevo, Center Municipality. The location is somewhat away from the city center towards the slopes of the Kromolj hill. The longer side of the parcel is both east and south oriented. The site is accessible from the local road and has certain infrastructure assets, which include electricity and water supply. Gas installations are 50m away from the plot. The plot is located at an elevation of 695 m, and its geographical coordinates are as follows: 43″53′23.08 north latitude and 18″24′38.56 east longitude. The new house was rotated by 15 degrees southward in relation to the existing building so that the longest sides of the house could be exposed to the south in order to make the glazed planes absorb as much solar energy as possible during the winter period, which is then converted into heat energy.

Figure 1: Google Earth – location

Figure 2: Site plan

Figure 3, 4, 5: House design – 3d model

Total heated area (A)	268 m^2
Total heated volume (V)	743 m^2
Total envelope area (Ae)	580,28 m^2
Total openings area (Aw) m^2	73
Window factor (Aw/A)x100	27
Compactness ratio	*0.78*

Table 1: Information about the house

Table 1 indicates the relation between certain components that form a part of the design. The most relevant parameter is a so called *compactness ratio*, which is 0.78, meaning that this building has a very large external envelope, i.e. physical separator between heated and unheated space, which is the architectural concept used in this particular design. This design was produced with several inputs in mind: the wishes of the family members who will live in the house and with whom the author defined the project and certain components of the building, and also the geodetic survey of the site on which the building was supposed to be erected, and that is an east and south oriented slope. Rotation of the building should provide more openness towards south, securing accumulation of the solar radiation in winter, and establish a visual contact of the interior with the outside greenery. Terrain evaluation was carried out in terms of stability and consistency of groundwater flows. Analysis showed that this is a relatively stable ground with few groundwater flows. These data were taken into consideration while selecting the heating systems, which will be explained further in the text. Overall envelope surface area is 580.28m^2. The window factor is 27, which means there is a large proportion of transparent in relation to nontransparent planes. Given these planes have the largest *U* factor they constitute major problems associated with reducing the amount of energy needed for heating.

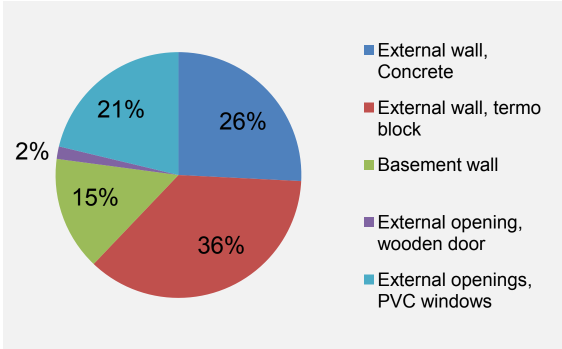
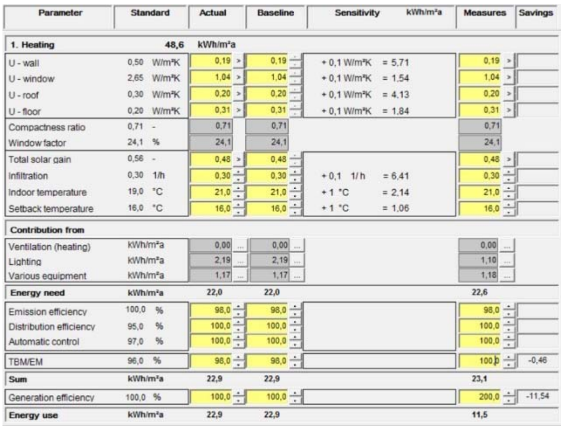


Diagram 1: Envelope structure

The envelope elements have approximately the same *U* factor values, and they are as follows: flat roof U factor is the lowest and amounts 0.13, wall U factor is 0.15 and floor U factor is 0.32. Heat transfer coefficients could have been even lower, but this would increase the investment costs by large, whereas the effects would not be significantly improved, unless the client decided to install certified passive house windows, whose coefficient does not exceed 0.8w/m^{2}K. The envelope was designed as to be active, that is, to control the energy inflow: south, east and west façades contain the largest number of windows, whereas the north façade is completely closed. The walls are massive structures which absorb large amounts of heat, which is at night released into the interior.



Parameter	Standard	Actual	Baseline	Sensitivity	kWh/m²a	Measures	Savings
1. Heating	48,6	kWh/m²a					
U - wall	0,50 W/m²K	0,19	0,19	+ 0,1 W/m²K	= 5,71	0,19	
U - window	2,65 W/m²K	1,04	1,04	+ 0,1 W/m²K	= 1,54	1,04	
U - roof	0,30 W/m²K	0,20	0,20	+ 0,1 W/m²K	= 4,13	0,20	
U - floor	0,20 W/m²K	0,31	0,31	+ 0,1 W/m²K	= 1,84	0,31	
Compactness ratio	0,71 -	0,71	0,71			0,71	
Window factor	24,1 %	24,1	24,1			24,1	
Total solar gain	0,56 -	0,48	0,48			0,48	
Infiltration	0,30 1/h	0,30	0,30	+ 0,1 1/h	= 6,41	0,30	
Indoor temperature	19,0 °C	21,0	21,0	+ 1 °C	= 2,14	21,0	
Setback temperature	16,0 °C	16,0	16,0	+ 1 °C	= 1,06	16,0	
Contribution from							
Ventilation (heating)	kWh/m²a	0,00	0,00			0,00	
Lighting	kWh/m²a	2,19	2,19			1,10	
Various equipment	kWh/m²a	1,17	1,17			1,18	
Energy need	kWh/m²a	22,0	22,0			22,6	
Emission efficiency	100,0 %	98,0	98,0			98,0	
Distribution efficiency	95,0 %	100,0	100,0			100,0	
Automatic control	97,0 %	100,0	100,0			100,0	
TBM/EM	96,0 %	98,0	98,0			100,0	-0,46
Sum	kWh/m²a	22,9	22,9			23,1	
Generation efficiency	100,0 %	100,0	100,0			200,0	-11,54
Energy use	kWh/m²a	22,9	22,9			11,5	

Figure 6: A detail from the ENSI software

Ventilation system was not designed, because venting out is done by means of controlled openings on the ground floor and in the part of the single pitched roof, where, due to the difference in pressures, air can circulate inside the entire house. On the northern façade recuperators have been installed, allowing the air to flow into the building with controlled temperature values. The calculation of energy needs carried out in both of the aforementioned computer programs showed results of 23kwh/m^2/year, which are great, especially if the safety factor is added, which then means that heating requirements are 30kwh, and energy needed for preparation of domestic hot water is 12kwh/m^2/year.

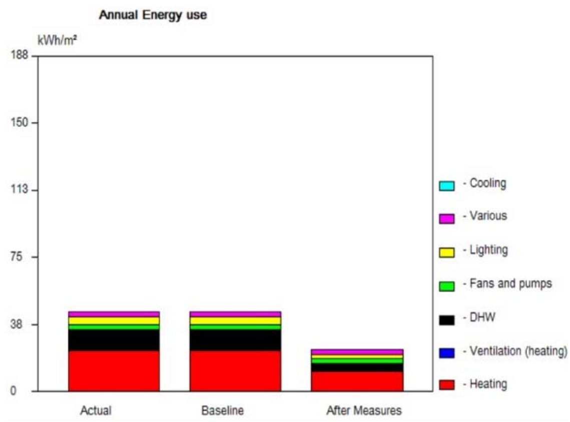


Figure 7: A detail from the ENSI software

Heating requirements of 30kwh/m^2/year need to be secured somehow and properly emitted in the house. Even though the investment costs have already been increased due to the increased quality of the envelope, here money becomes an issue again. Modern technology offers many solutions for efficient energy use and production. Analysis of the microclimate and soil structure showed that installation of a heat pump would be one of the best long-term solutions. The pump used in this case is the air to water heat pump, which can be used even if the outside temperature is below 20°C. In this way, the energy needed for heating would be reduced by 2 or 2.5 times, and in this way the house could become a house with a 15kwh/m^2 heating demand, which was ultimately the objective of this project. The central system also includes preparation of domestic hot water, supported by the diffuse light solar panels installed on the roof. They transfer solar energy into the central boiler, which heats the water with the help of the energy obtained from the heat pump. Finally, the energy need will be reduced from 45kwh/m^2 to 18kwh/m^2 with zero CO_2 emission, which is an exceptional result given the time and place in which the referenced project was designed and executed.

Another example is a building located in Sarajevo, which has been under construction for more than a year now. It is located in the old part of the city, in the neighborhood called Vrbanjuša. The original building was a typical villa from the Ottoman period. This house is listed as a more than 350 year old house. During the reconstruction it was completely demolished and a new building was designed, but only partially built. During the second phase of the construction the client asked the architect Haris Bradić to make a new design, on which occasion designs of the courtyard, interior and energy efficiency were produced. The house is located at an elevation of 611m, with the following geographical coordinates: 43″51′58.46 north latitude and 18″24′45.72 east longitude. This position is similar to the previously described example, but with certain differences. The house has a basement, ground floor, first floor and loft. Orientation-wise, the house has a very good position, because there is an unobstructed accumulation of solar energy from all sides throughout the entire day.

Figure 8: Google Earth – Location

Figure 9: Court yard and ground floor plan

Figure 10,11: House design – 3d model

Figure 12: Existing condition as of 2012.

Total heated area (A)	449,26 m^2
Total heated volume (V)	1124 m^3
Total envelope area (Ae)	732,33m^2
Total openings area (Aw) m^2	100,95
Window factor (Aw/A)x100	22
Compactness ratio	*0,65*

Table 2: Information about the house

Table 2 shows that the compactness ratio is better than in the previous example, because the shape of this house is a cube with minimum disruptions to the façade, except on the entrance. Total heated area is quite large and it requires large heating demands. One of the main reasons for this is not a very low *U* factor of the external walls whose values range between 0.31 and 0.39W/m^2K, and which take up 55% of the entire envelope. The building's heating demands are 52kWh/m^2/year, and those for preparation of domestic hot water amount to 13.7 kWh/m^2/year. Total energy need of the house is

75kWh/m^2/year, which is a quite large value in energy efficient architecture. According to the design, all of the aforementioned parameters should be decreased by using the energy from the ground and installing five 100m probes and two ground source heat pumps, connected into one system which is supported by the system with thermal energy obtained from diffuse light solar panels installed on the roof. In this way, the overall energy need will be 21kWh/m^2/year. If more attention was given to the envelope in the very beginning of the project, the aforementioned energy need could have been reduced even to 15kWh/m^2/year, with zero CO_2 emission.

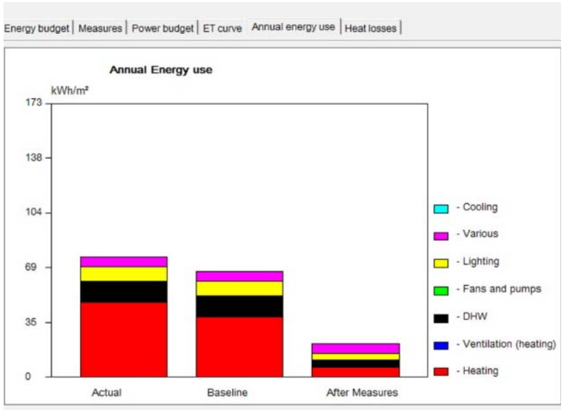


Figure 13: Taken from the ENSI Software

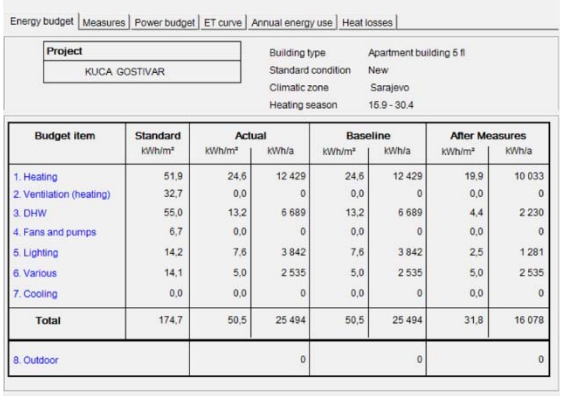
Third example is a house in Macedonia, Senekos near Gostivar, Tetovo, Macedonia, which is still under construction. The area has similar climate as Sarajevo, with cold winters and warm summers. The design of this house is based on the traditional architecture which had been present in the territory with mainly Albanian population for more than 5 centuries. Such architecture is manifested as individual residential structures with multi-pitch roofs, usually housing ground and first floors, surrounded by greenery within high walls enclosing the entire property. The main purpose of this design was to combine the aforementioned tradition with contemporary human needs. This resulted in a building with a basement, ground floor, first floor and loft.


Figure 14, 15, 16: House design – 3d model

Total heated area (A)	505 m^2
Total heated volume (V)	1361 m^2
Total envelope area (Ae)	1079 m^2
Total openings area (Aw) m^2	133,93
Window factor (Aw/A)x100	26
Compactness ratio	*0,79*

Table 3: Information about the house

Irregular angles of the façade which separates the interior and outside greenery by means of large glazed planes, with overhangs above the ground floor, increased the size of the envelope, which negatively affected the overall calculation of the building's energy needs. The data obtained upon calculation show that the compactness ratio is 0.79, with large heated air volumes and large envelope that serves as a boundary between the interior and exterior. The decision was made together with the client that particular attention should be given to proper design of the envelope, that is, the U factor of walls, floors and roofs must not exceed 0.15 W/m^{2}K, and that of external openings 0,9 W/m^{2}K. Even though the end result was a structure of a very complex shape in terms of energy efficiency, the total energy demand for heating and preparation of domestic hot water of 37kWh/m^2 *per* year is an excellent final result and confirmation that every architectural concept can become energy efficient provided that significant financial resources are available. This building will not have a controlled cooling system, which might be a slight negative aspect, but as for the heating, the house will have a central system with a pellet boiler supported by solar collectors on the roof. The aforementioned system will contribute to reducing the overall energy needs required for heating and preparation of domestic hot water to 25kWh/m^2 *per* year, making this house the first low-energy house in Macedonia with very low carbon emission. Cooperation between the client and designer in this project was excellent, which ultimately led to the above mentioned results and construction of an energy efficient house.



Energy budget | Measures | Power budget | ET curve | Annual energy use | Heat losses

Project: KUCA GOSTIVAR

Building type: Apartment building 5 fl
Standard condition: New
Climatic zone: Sarajevo
Heating season: 15.9 - 30.4

Budget item	Standard	Actual		Baseline		After Measures	
	kWh/m²	kWh/m²	kWh/a	kWh/m²	kWh/a	kWh/m²	kWh/a
1. Heating	51,9	24,6	12 429	24,6	12 429	19,9	10 033
2. Ventilation (heating)	32,7	0,0	0	0,0	0	0,0	0
3. DHW	55,0	13,2	6 689	13,2	6 689	4,4	2 230
4. Fans and pumps	6,7	0,0	0	0,0	0	0,0	0
5. Lighting	14,2	7,6	3 842	7,6	3 842	2,5	1 281
6. Various	14,1	5,0	2 535	5,0	2 535	5,0	2 535
7. Cooling	0,0	0,0	0	0,0	0	0,0	0
Total	174,7	50,5	25 494	50,5	25 494	31,8	16 078
8. Outdoor			0		0		0

Figure 17: Calculation results, ENSI software

CONCLUSION

Construction of energy efficient architecture in developed countries is a common standard nowadays, whereas in developing countries, such as Bosnia and Herzegovina, this is still a quite big issue. This paper presented three houses which are currently being built and which represent positive examples where clients recognized, in the long run, the quality of energy efficient construction. Payback period calculations show these investments are not yet cost-effective due to both low price of energy sources in our region and price of the systems that use renewable energy resources, including the solar, wind and geothermal energy, but it is expected that this will change in the near future and consequently lead to construction of large numbers of buildings with the above mentioned characteristics. Every region is distinct in terms of using renewable energy sources, and therefore architectural designs, which define the benefits of a certain area, are very important [1]. One particular point can be emphasized here, and that is the exploitation of the solar energy, both in terms of absorption and protection from excessive radiation during summer periods by properly planning the orientation of a building, designing adequate layouts and envelopes. In all three examples mentioned above building physics equations were used to calculate the energy flows through the boundary between heated and unheated space, whereas the standards regarding construction of passive and energy efficient buildings were taken from the German Passivehause Institute in Darmstadt. [4]

Finally, the entire process can be divided into several phases: thorough analysis of the site's microclimate [3], precise definition of the design with the client, focusing on the overall budget, detailed calculation and simulation of energy flows from the inside towards outside and *vice versa*, in cooperation with different engineers, including mechanical and electrical engineers, and finally creation of a concept for energy production for a particular structure, both in terms of renewable energy sources and pricing. The main objective of the projects was achieved, and that is energy independent architecture with minimum CO_2 emission.

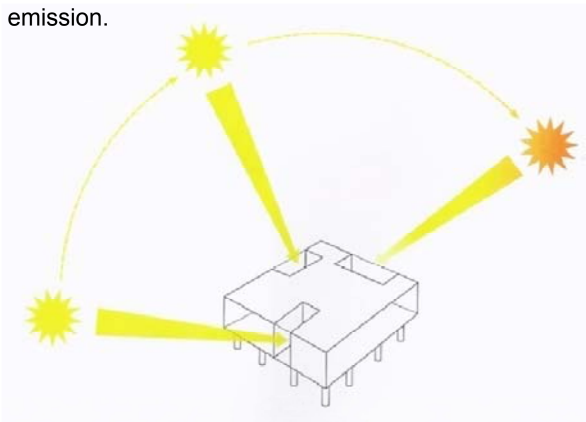


Figure 18: Exploitation of solar energy [1]

REFERENCES

[1] Duran, S.C.: *Architecture & Energy Efficiency*, Publisher: Loft Publications, 2011., Barcelona, Spain

[2] Hadrovic, A.: *Architectural Physics* – new edition, Publisher: Faculty of Architecture in Sarajevo, 2010., Sarajevo, BiH

[3] Hadrovic, A.: *Bioclimatic Architecture*, Publisher: Faculty of Architecture in Sarajevo, 2008., Sarajevo, BiH,

[4] Schoch, T.: *EnEV 2009 und DIN V 18599 Wohnbau*, Publisher: Bauwerk, 2010., Berlin, Germany,

[5] Sternthal, B., Eisenberger, H.: *Die Schonsten Passivhauser*, Publisher: Christian Brandstatter Verlag, 2011., Vienna, Austria

An Optimization Method For Green Design of Office Buildings

A. Ganjidoost
Department of Building, Civil and Environmental Engineering, Faculty of Engineering
Concordia University, Montreal, Quebec, Canada

Abstract
To date, few studies have been done in order to assess the environmental impacts of office buildings through their life cycle. Also, few studies in the field of life cycle costing (LCC) of office buildings have been represented in the literature. However using linear optimization to balance between life cycle assessment (LCA) and LCC of office buildings has not been investigated. This paper presents a framework to optimize LCC and LCA of office building. The emphasis is on the relationship between reducing environmental impacts as a system targets and minimizing the LCC and global warming potential of office building. This framework is a pattern for the stakeholders of a project as users to enter their inputs and decide between alternatives based on the environmental impacts indicators in a LCA process, and also, LCC of office building. A hypothetical case example is applied to demonstrate the application of the purposed optimization framework. The results of LCC and LCA have been used in the model to find the optimum solution.

Keywords:
Green building, Sustainability, Optimization, Life cycle analysis, Office buildings

1 INTRODUCTION

The objective of this research is to develop an optimization model of environmental analysis and life cycle cost of office buildings in Canada towards sustainability.

Sustainable building integrates building materials and methods that promote environmental quality, economic vitality, and social benefits through the design, construction and operation of the built environment. Sustainable building merges sound, environmentally responsible practices into a discipline that looks at the environmental, economic and social effects of a building or built project as a whole. The American Society of Civil Engineering (ASCE) defines sustainability as “systems designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological and engineering integrity” [1]. A definition of office building concept helps understanding better of the research framework. [2] gives the following description for office buildings. “Buildings used for general office space, professional office, or administrative offices. Medical offices are included here if they do not use any type of diagnostic medical equipment (if they do, they are categorized as an outpatient health care building)”. This study is based on the above definitions.

The concept of green building design is mitigation of impacts on environment while considering cost and other criteria of performance. Green design consists of the practices which significantly reduce the negative impact of buildings on the environment and are categorized in five areas: sustainable site planning, safeguarding water and water efficiency, energy efficiency and renewable energy, conservation of materials and resources, indoor environmental quality.

2 LIFE CYCLE COSTING (LCC)

American Society for Testing and Materials (ASTM) defines LCC as a technique that “justify a certain expenditure on a project/system by proving its saving along its life span” [3]. LCC analysis is a forecasting the financial performance of a building or system over the period of study. Equation 1 represents the components of LCC, which includes the present value of investment costs, energy costs, operating and maintenance costs, repair and maintenance cost and the cost of salvage value [4]. LCC can presents in both present value (PV) and annual value (AV). The LCA is not the same as LCC. The two methodologies are complementary, but LCC focuses on the dollar costs of building and maintaining a structure over its life cycle, while LCA focuses on environmental performance. Performance is measured in the units appropriate to each emission type or effect category.

$$LCC = Ip + Ep + Mp + Rp - Sp \qquad (1)$$

I: investment cost

E: energy cost

M: non fuel operating and maintenance cost

R: repair and maintenance cost

S: salvage value

P: represents the present value

3 LIFE CYCLE ASSESSMENT (LCA)

A LCA is a systematic, cradle-to-grave process that evaluates the environmental impacts of products, processes, and services. LCA considers the impacts of the building on environment over all phases throughout its life cycle stages which are: raw materials acquisition, manufacturing, use / reuse / maintenance and end-of-life (recycle / waste management) [5]. The environmental impact of this study measured in Primary Energy (MJ), Solid Waste (Kg), Air Emissions (index), Water Emissions (index), Global Warming Potential (GWP) (Kg) and Weighted Resource Use.

Several softwares have been developed to measure the environmental implications of industrial, institutional, commercial and residential designs–both for new buildings and major renovations. The environmental indicators used in the study methodology, is based on the Athena Sustainable Material Institute [6].

4 METHODOLOGY FRAMEWORK

With the principles of the green design and also, the definition of sustainability, the sustainable and green design for office buildings can define a building with reserving the natural resources and most cost effective. The framework of this study is based on the principles of sustainability and green design. The Methodology framework described in the present paper can categorized as following:

- Collecting the data in order to be use into LCA and LCC process of office building.
- Analyzing the environmental impacts and calculating cost of an office building throughout its life cycle for several alternatives.
- Defining objective constrains and targets of the optimization framework in order to reach the objectives of the study.
- Developing the optimization model to select the optimal alternative.

5 OPTIMIZATION METHOD

Optimization method is a way of finding the optimal solution which meet or exceed the targets of the optimization model. An optimization model is based on the objective function which is seeking to minimize or maximize the objective function. It has one objective or multiple objectives. In definition of Radford 1987, optimization is an automated process incorporating three steps: generation, simulation, and evaluation [7].

The optimization model of this study guides the designer and decision makers to achieve the sustainability targets that are the most cost effective and also, have the lowest environmental impacts. The objective of the optimization model in the present study is minimizing the life cycle cost and GWP of office building. This model finds the optimum solution between alternatives components of the office buildings. Equation 2 represents the description of the model.

$$Minimize \sum allA(L_A + G_A) \quad (2)$$

Subject to

$$\sum allAEI_A \leq EI*$$

Where:

A: Component of Building (1 to N)

L_A: Life cycle cost of component A

G_A: Global Warming Potential of component A

EI_A: environmental impacts I of component A

EI *: targets of environmental impacts

Constrains (EI)

Constrains of the optimization model are the environmental indicators of the Athena which are the results of the l life cycle assessment of office building. These constrains are as following:

- Primary Energy
- Air Emission
- Solid Waste
- Water Emission
- Global Warming Potential
- Weighted Resources Use

Variables

The variables of the present optimization model are the different alternatives to the components of base office buildings including base office building itself (X_1 to X_N). These variables shown as following:

Equation 2 is expanded as following:

$$Minimize$$

$$(L_1+G_1)X_1+(L_2+G_2)X_2+...+(L_N+G_N)X_N$$

Subject to

EI is Primary Energy:

$$EI_1X_1+EI_2X_2+...+EI_NX_N \leq EI*$$

EI is Air Emission:

$$EI_1X_1+EI_2X_2+...+EI_NX_N \leq EI*$$

EI is Solid Waste:

$$EI_1X_1+EI_2X_2+...+EI_NX_N \leq EI*$$

EI is Water Emission:

$$EI_1X_1+EI_2X_2+...+EI_NX_N \leq EI*$$

EI is Global Warming Potential:

$$EI_1X_1+EI_2X_2+...+EI_NX_N \leq EI*$$

EI is Weighted Resources Use:

$$EI_1X_1+EI_2X_2+...+EI_NX_N \leq EI*$$

Global Warming potential (GWP) Cost

In order to minimize life cycle cost and global warming potential the unit of GWP has to equalize the LCC. To achieve this issue, GWP measured in a CO_2e and then translated to a monetary value. In this approach the units of both objectives equalized. It is converted to an equivalent CO_2 then the quaintitatived CO_2e translated into a monetary value of CO_2 emissions. The price of CO_2e is taken from the actual stock markets.

Equivalent CO_2 extracted from the results of the LCA process then it converted to a monetary value based on Kyoto protocols. Figure 1 shows the framework of this translation.

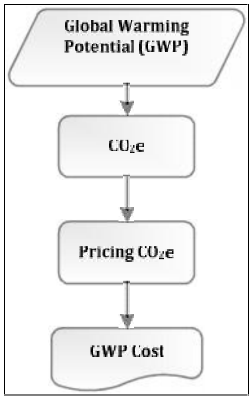


Figure 1 Framework of translating CO_2e to a monetary value

LINDO

LINDO (Linear Interactive and Discrete Optimizer) is optimization programming software which applied to solve linear, integer and quadratic programming problems. LINDO minimize or maximize an objective function. If the programming problem intends to minimize or maximize multiple objectives function subject to a set of constrains, LINDO cannot be used. Also, it carries the maximum of 200 variables and 100 constrains. The optimization model represented in the previous section is going to minimize a dual objectives function subject to a set of constraints (environmental indicators). Since the units of the objectives (LCC and GWP) are equalized, therefore the model is going to minimize only one objective as a linear function of office building alternatives (decision variables).

6 OPTIMIZATION MODEL HYPOTHETICAL CASE

This section represents a hypothetical case with some assumed date to see the process of the optimization model.

Some data assumed for environmental indicators and for calculating TLCC. In a real case the environmental indicators are resulted from entering real data of office building components to a LCA process, and TLCC is calculated through the collection of real data of building components. Then the environmental indicators and TLCC of different variables are entered as inputs to the proposed optimization model and through the optimization model process using LINDO programming software (equation 3.1), the optimal solution is obtained. Variables of X_1, X_2, X_3, and X_4 are assumed.

6.1 Environmental Indicators

Six environmental indicators of primary energy, air emission, solid waste, water emission, global warming potential and weighted resource use are used in the hypothetical case:

X_1:

- Primary Energy = 952000 MJ
- Air Emission = 198000 Index
- Solid Waste = 1205000 Kg
- Water Emission = 4566750 Index
- Global Warming Potential = 955060 Kg
- Weighted Resources Use = 400380 Kg

X_2:

- Primary Energy = 10525000 MJ
- Air Emission = 203450 index
- Solid Waste = 71940000 kg
- Water Emission = 5568900 index
- Global Warming Potential = 1056070 kg
- Weighted Resources Use = 780300 kg

X_3:

- Primary Energy = 10434000 MJ
- Air Emission = 214520 index
- Solid Waste = 74250000 kg
- Water Emission = 5566780 index
- Global Warming Potential = 1084030 kg
- Weighted Resources Use = 770400 kg

X_4:

- Primary Energy = 933000 MJ
- Air Emission = 189000 index
- Solid Waste = 699000 kg
- Water Emission = 4566700 index
- Global Warming Potential = 902566 Kg
- Weighted Resources Use = 450600 Kg

6.2 Life Cycle Costing

The following assumed data are used to calculate the life cycle costing of variables X_1, X_2, X_3 & X_4 in terms of present value (PV). The bank discount rate is 4% and the design life span is assumed to be 40 years (table 1).

6.3 Environmental Life Cycle Costing

The cost of Global warming potential or cost of Co_2e in term of ton is obtained from www.pointcarbon.com.

G 1: 955060 × \$19 = \$18,146.140

G 2: 1056070 × \$19 = \$20,065.330

G 3: 1084030 × \$19 = \$20,596.57

G 4: 902566 × \$19 = \$ 17,148.754

6.4 The Optimization Model

The objective of the optimization model is to minimize total life cycle costing subject to a set of constrains. In order to run the optimization model the targets were equalized to the environmental indicators of variable X_1. For instance primary energy could not exceed 952000 MJ. Figure 2 shows the LINDO programming of the hypothetical case.

```
LINDO Programming of Hypothetical Case
!Let X1 be Alternative One
!Let X2 be Alternative Two
!Let X3 be Alternative Three
!Let X4 be Alternative Four
!
!objective: Minimize Total Life Cycle costs
!
min 3437306 X1 + 3799755 X2 + 3994966 X3 +
3401500 X4
!
subject to
!the following constrains
!
!Primary Energy
952000 X1 + 10525000 X2 + 10434000 X3 + 933000 X4
<= 952000
!
!Solid Waste
1205000 X1 + 71940000 X2 + 74250000 X3 + 699000
X4 <= 1205000
!
!Air Emission
```

Figure 2 LINDO programming of the hypothetical case

6.5 Hypothetical Case Results and Discussion

The result of the LINDO optimization programming using equation 2 found that variable X_1 met all the targets with lower cost. Therefore the optimal solution is variable X_1. There are other methods to choose the most cost effective alternative in a project such as cost-benefit analysis. This paper chose an optimization method because the goal of this research is not only choosing alternatives based on cost efficiency. Mitigation of environmental impacts is also an objective of this paper which can obtain in an optimization approach with balancing between the total LCC and LCA of the project. Thus the optimum solution is the most cost effective which has totally the least impacts on environment during the life design of the building.

7 CONCLUSION AND FUTURE WORKS

This paper proposed an optimization model for balancing between LCC and LCA of office buildings. LCC and LCA and concepts were reviewed. This paper figured out the methodology framework of the study and then developed the methodology. The equation of optimization model has been defined and the model's framework including objective, constrains and variables of the model were explored.

Furthermore, this paper applied the methodology of the research to a case example to observe the mechanism of the model. The results of the case example were found the optimum alternative of base office building which is the most cost effective and has the lower environmental impacts.

Stakeholders of a project must not only find the quickest way to complete their work but also the most-cost efficient way and least impacts on environment. The human population has an undisputed need for comfort and ease, which supersedes environmental conscious decisions. However, as the population increases, human must find a way to deal with depleting resources fundamental to their existence.

Finally this paper considers the economical and environmental impacts of office building throughout its life cycle. There are other effects which built of an office building can caused on environment such as social effects. For example what are the impacts of an office building construction on the people life or what is the impact on the businesses around the new construction. These type of the impacts can also, include in future works which needs a collaboration of experts people from different related area like engineering, sociologist, architectural and etc.

8 REFERENCES

[1] ASCE Code of Ethics date from 1996

[2] Dell' lsola, A.J. and Kirk, S.J. (1981). "Life cycle costing for design professionals", McGraw-Hill, New York. 113. Page 6.

[3] ASTM International (1999), Standard Practice for Measuring Life-Cycle Costs of Buildings and Building Systems, ASTM Designation E 917-99, West Conshohocken, PA.

[4] Robert P. Charette, Harold E. Marshalle "Uniformat II Elemental Classification for Building Specifications, Cost Estimating, and Cost Analysis" U.S. Department of Commerce Technology Administration, National Institute of Standard and Technology, NISTIR 6389, 1999

[5] LCA principle and guides, EPA (Environmental Protection Agency), USA 2009

[6] Athena Sustainable Material Institute (2010) Athena Impact Estimator, Version 4, Merickvile, Ontario, Canada.

[7] Radford, A.D., and Gero, J.S. (1987). "Design by optimization in architecture, building and construction". New York: Van Nostrand Reinhold Company.

	Cradle to construction ($)	Annual maintenance and repair ($)	End of life ($)
X_1	2,356,460	25,680	35,500
X_2	2,768,690	24,350	37,000
X_3	2,957,870	24,450	38,500
X_4	2,445,652	22,580	35,500

Table 1: Calculating life cycle costing of variables X_1, X_2, X_3 & X_4.

Interplay of Internet of Things, cloud computing and sensor networks in people and goods mobility in design of future smart and green cities.

Adnan Salihbegovic[1]
[1]Faculty of Electrical Engineering,
University of Sarajevo, Bosnia Herzegovina

Abstract
Future smart and green city design is inseparable from the effective solution of mobility of people and goods in the populated areas of large cities. Public and fright transport traffic of future cities shall heavily rely on the future Internet connections wired and wireless and speed that shall be available; on the waste amount of real-time information available from Internet of things and huge computing capacities of the cloud computing in these networks. Traffic control operations shall be hosted in the Internet, in secure virtual traffic controllers and a virtual traffic centre, leaving local physical traffic control systems the task of providing safety controls in case of Internet communication failure.
The paper is dedicated to analysis of the trends in network technologies, sensor devices design and cloud computing and their interplay and interactions in ITS systems, enabling the implementation of above envisaged scenario for people and goods movements in future smart and green cities.

Keywords:
Intelligent transportation systems, Future internet, Internet of things, sensor networks, cloud computing, smart and green cities,

1 INTRODUCTION

The integration of information and communication technologies (ICT) in the cities transportation system (infrastructure, vehicles and traffic management) is one of the main approach for solving mobility of people and goods in urban areas when planning and building future smart and green cities.

This drive is part of wider technical wave of designing and building intelligent transportation systems (ITS) making transport systems intelligent through the use of ICT, introducing the notion of “smart mobility” used in particular with mobility in future smart and green cities [1].

Future Internet of services is based on four pillars: Internet of things, Internet of people, sensor networks and cloud computing. They are not goal in itself, but rather a means to meet the challenges of future transport objectives and mobility in the cities that are : resource efficient, environmentally friendly and seamless across all transport modes for the benefit of citizens, the economy and societies as a whole.

More than 80 percent of European population lives today in urban areas and large cities. Mobility of their citizens and transport of the goods and services often leads to the number of problems, such as traffic congestion, increased pollution levels and greenhouse gas emissions, or excessive travelling time and energy consumption, making these cities unfriendly and unhealthy for living. To solve these problems and return nature and healthy living to the citizens, the notion of smart and green city was coined. The implementation of concepts and ideas from Intelligent Transportation Systems (ITS) based on new technologies and services of Future Internet including adoption and large scale deployment of vehicle-to-vehicle (V2V), vehicle to pedestrian (V2P) and vehicle-to-infrastructure (V2I) technologies, shall become common strategy in planning and designing future cities [2]. But deployment of these technologies and associated infrastructures require lots of time and investment money that shall be available and affordable only to economically successful societies.

2 TECHNOLOGIES BEHIND ITS

2.1 Fixed communication networks

Fixed communication networks with their massive and complex infrastructure based on copper or optical cables are spanning today many cities in developed but also developing countries. The main trend in the future is deeper penetration of fiber in the core and backbone networks. Fixed communication networks offer up to ten times more bandwidth than mobile communication network channels.

For fixed networks operators, bandwidth of their networks is the main asset enabling them to innovate and include broadcast or multicast services, which were traditionally on-air services attributed to wireless radio networks. The competition between fixed and mobile networks in providing communication services for all city users including ITS, is expected to reach its peek between 2015 and 2020 when LTE and 4G mobile technologies will be available not only in USA but also in Europe and other continents.

Fixed networks were built for one to one communication when Internet provides a common access for many users of the same content. Future Internet shall provide multicast protocols for fixed networks to optimize utilization of bandwidth resources. User devices will integrate multicast intelligence to manage the right level of quality of service and to build, on-the-fly, the desired partition of fixed networks end-users to define real-time and no-permanent virtual private networks.

Fixed networks, which are dedicated to a limited set of devices, shall also provide common access to Future Internet (FI) for all connected devices at home in a professional and city infrastructure environment. This convergence shall be supported by new protocol adaptation layers and new interfaces for devices. Smart connection boxes shall become the main network interface, bridging all wireless technologies with fixed networks, integrating homes, offices and city infrastructure “in the cloud”, to deliver computational resources “as a service” [3].

2.2 Wireless networks

In the context of building intelligent transport systems as backbone of future smart mobility of people and goods in city, we shall briefly review only wireless radio communication technologies that shall be used in V2X connections.

V2X radio technologies are based on 802.11p which is expected to support Intelligent Transportation Systems (ITS) and associated devices in environments "where the physical layer properties are rapidly changing and where very short-duration communications exchanges are required". This standard provides a two-way, short-range wireless communication very similar to Wi-Fi technology (802.11b, g, n).

V2X technology expects to assess the surrounding vehicle environment based on accurate and precise data exchanges with other vehicles and roadside hotspots. The data exchanges include several elements: a vehicle's location, velocity, acceleration and travelled path history, which can enable on vehicle computers to predict trajectories and reduce the likelihood of collisions.

V2X are split in three categories, based on the communication characteristics of one of the receiver:

• (V2V): vehicle to vehicle

• (V2I): vehicle to infrastructure (road infrastructure)

• (V2P): vehicle to pedestrian

One of the main challenges for V2X technologies is the definition of DSRC devices (Dedicated Short Range Communication) because they will use "dedicated" short range communication. Having mobile and embedded devices installed in moving vehicle (V2V), mobile and portable devices (V2P) or static devices installed in transport systems infrastructure (V2I), that variety of installation and operation environment shall increase the complexity of mobile systems and split them up in separate devices. V2X technologies shall provide vehicle awareness to avoid any conflict and damage on the road, but also traffic awareness with a better knowledge of vehicles flows in a city and shall be integrated in many traffic control system services discussed further on...

2.3 Internet of Things

Internet of Things (IoT) is another term in frequent use when talking about Future Internet (FI). Internet of things represents not only a sensor network to collect data, in which smart and programmable sensors are equipped with IP address (IP V6) and able to send information they collect and process to any internet connected device. Internet of Things also includes smart devices which can act independently depending on rules, processes and context awareness [4].

Internet of Things should not be replaced for a virtual world where all smart things would interact together without any human interactions. Internet of Things shall provide the best services for human beings, which are part of the processes and rules. People are the context awareness system for smart things and their prime users.

Currently, there are in use several protocols to support dedicated interconnections among smart devices and sensor networks in specific areas of applications like:

• EPCGlobal standard for RFID tags, used mainly for tags as passive RFID devices which extract energy from the receiving signal sent from active device (used in warehouse management) [5].

• 6LowPan or Zigbee with very low energy consumption used in AMR (automatic meter reading) [6].

• ITS protocol and standards for interconnected vehicles [7].

Further characteristic of (IoT) is to enable smart devices to identify, discover and manage things (sensors, smart devices like smart phones often named "nomadic devices", etc.) connected to Internet.

Future development in the area of Internet of things has to achieve the goal of real-time and always-on connectivity. Today, Things are available on Internet from time to time based on connectivity and energy concerns since sensors and other types of Things are autonomous devices with limited battery capacities for electric power supply. Future Internet and (IoT) shall be built on ever decreasing low power electronic components for longer autonomy. Connection with "nomadic"smart Things shall require new tools to analyze in which context smart things shall communicate and in which protocol and format will exchange data.

2.4 Cloud computing

The term "Cloud computing" stands for the use of computing resources (hardware and software) that are physically installed at certain locations belonging to providers, and delivered as a service over any type of computer network, typically over Internet (wired or wireless) [8].

The generic name of the service is designated as "XaaS" and refers to all types of resources which could be provided "As A Service" and are not hosted or owned directly by the end user, e.g. customer of the service.

Initially term was used for „Software as a Service"(SaaS) which covers a new way to utilize application software, in the beginning through elementary features and limited number of users. Later in time this technology has evolved to deliver the right Quality of Service for using application software for many more consumers.

Newer extensions of this approach of "As a Service" have included many more services like:

- (IaaS) which includes computer infrastructures to host physical resources for distributed storage,
- (PaaS) standing for platform as a service and designates the configurations when remote computer hardware and software resources, connected via fast internet connection, are used to create virtual machines (VM) on which user develops and runs his applications with required level of reliability and security [9].

Future Internet and XaaS technologies will be opened and shall provide common access to all resources and represent basic building blocks for computing infrastructure of future ITS systems in design of traffic control centres of future smart and green cities.

2.5 Mobile technologies and localisation

Localisation services are one of the most valuable information provided by sensors and nomadic devices on Internet of Things about people, vehicles and transportation infrastructure in cities and country-wide areas of their movements. This information has become possible when these services were launched by services players as Google but also by smart device manufacturers (Nokia, Apple, Samsung, LG, etc.) when they have decided to include GPS components in their mobile devices (phones, tablets, etc.).

In the future, new mobile communication technologies based on LTE and 4G, and on new network intelligence e.g. IMS core network [10], will be able to provide even more precise localisation information based on device localization in the network (identification of a mobile cell with which mobile device communicate and use of its high precision location data) with no additional cost, and with less battery drain of built-in GPS chip (service available in some newer smart phones as A-GPS).

This shall require an additional Location Network Service (LNS) to refine localization in a communication cell (base station), but this shall be based on more classical short messages system. Future Internet shall also provide roaming for localization services to enable that localization is always available independently of the selected mobile operator.

Furthermore, information on the altitude of the Thing location (sensor or nomadic device) shall be precisely determined with high precision absolute pressure transmitter that is going to be integrated in new MEMS devices embedded in smart devices [11].

3 FROM DATA TO TRAFFIC MONITORING AND CONTROL

Internet is the best support today to publish and share data that everyone could provide or use. In the application area of intelligent transportation systems (ITS), many types of data are available and real-time technologies and services based on them will increase significantly the number of data that transport participants could exploit to improve services.

There is no common format for various types of traffic data, fleet management data, location data of vehicles or people, payment data etc. Definition and acceptance of a common interoperable standard will take long time to generate and be broadly accepted.

Internet, based on cloud services, can host all these data in their respective format and new models and algorithms will be able to extract relevant information for transport area depending of the service objectives.

In the area of parallel processing of huge amount of data in real-time as expected from transport related services based on sensory data, various techniques of parallel processing of code and data on new generation of multicore processors are entering the embedded systems arena, not only for application and data servers but also for hand held devices, smart phones and smart sensors (for example new Samsung Galaxy Note II uses Nvidia 1.6 GHz quad core processor [12]).

There are already available many programming methods, tools and languages to support parallel programming techniques on these multicore processors [13].

Since future services in build-up of intelligent transportation systems include real-time location and need to share large amount of personal data, two main research topics regarding security and privacy are to be dealt width:

• Access right management

• Anonymous mechanisms of handling user data

These two critical technical issues shall be complemented by strong security mechanisms to avoid networks attack, as all people and vehicles will be interconnected over the networks when these data are exchanged.

Within the scope of access right management, Future Internet (FI) technologies will provide profiles management tools whereby the passenger's profiles will be associated to different transport services or how people expect to use different services depending of the context [14].

Based on this set of profiles, access rights will be managed cooperatively locally, as close as possible to the users, and in a central way for large numbers of citizens using the same type of profile. This dual approach will enable new policy rules and support some automated actions based on access right delegation.

Anonymous mechanisms of handling user data are a more challenging issue, especially because one has to manage these services close to the user.

ICT technologies shall require computational resources which are not readily available today. Some technologies are available to manage anonymous mechanisms in a central way, but this approach requires strong network security and certified third parties who are processing these data.

Future Internet technologies as of today are quite far away to support delegation of rights and revocation services when citizens will be able to define how long the data they agree to provide, will survive in the network and various databases, before delegation of rights are revoked by them and these personal data should be wiped off [15].

3.1 The real time traffic information

Today, there are many tools offering data for drivers and travellers on road traffic conditions, from a range of static to nearly real-time. The channels used to convey this information are websites, mobile applications, Radio Data Systems (RDS) for drivers and signalling panels on the roads (VMS – Variable Message Signs). However, there is a lack of such tools for the city traveller using public transport means, since these timetable information systems informing on vehicle arrivals at stops, are installed in only small number of large cities.

The more integrated and dynamic tools are proposed on smart phones, like the one developed by the Fraunhofer Institute in Germany [16].

The real time traffic data is provided by several types of actors:

- the road operators for main roads and motorways
- the local governments via traffic centres
- private service providers through mobile apps and variable message signs for drivers, public transport travellers and pedestrians
- PND (Personal Navigation Device): according to Market Research there are 200 million systems that contain a GPS function (they should be 283 millions in 2013) [17]
- GPS applications for smart phones (as Wikango, Waze5, etc.) [18]
- Public Transports Providers, but not very detailed traffic information on their networks, and is not multimodal. The mobile applications are owned by the transport operators.

The British foundation MySociety has launched an application, Fixmytransport [19], to enable public transport users (metro, bus and tramway) to provide feedback on malfunctioning of services to public transport authorities. In France CheckMyMetro [20] and MetroEclaireur [21] enable public transport users in Paris to share their comments on traffic, events, etc.

3.2 Predictive guidance services and traffic tools

Ford is making use of Google's Prediction API [22] to model driving behaviour based on driving history. IBM is testing smart phone technology that can predict traffic jams and warn commuters before they even start their journey [23].

The Traffic Prediction Tool, now being tested in the San Francisco Bay Area [24], analyzes real-time traffic data and commuter habits to identify any problems that might slow them down in commuting.

There exist on Internet many local web sites destined to help ride sharing but so far they don't propose dynamic ride sharing.

There are few solutions that use at the same time synchronizing real-time data and historical data to provide predictive and personalized services.

The personalization is not generalised: existing tools are based on geo location of the travellers and use the preferences declared by the user. But so far, there is no self learning tool capable to update the preferences of the traveller by a deep analysis of his habits and behaviour.

Instant Mobility project [25] , promises innovative services for the traveller that could be summarized in the following value proposition for the customer.

As a traveller, the Dynamic Multimodal Journey application will help him to plan and adjust the execution and the payment in real-time of a multi-modal journey from door to door with a single electronic ticket on a pay-as-you-go policy (dynamic pricing) [25] .

By accessing real-time traffic and transportation information via any mobile device, the travellers can easily identify alternative transit routes based upon personal preferences, the fastest route option, and the most convenient for them at the moment.

Instant Mobility shall provide travellers with highly integrated and for all means of transports, dynamic (real time events processing) and personalized information before and during their journey.

The values for the traveller will be:

- the ability, through centralization of all the data, to empower the traveller to make a better decision
- the performance and reliability to reduce unnecessary travel time;
- the ease of access: easiness to transfer from one transport to another (see Eurobarometer [4]) and sense of freedom due to integrated real time information and due to an integrated service, from planning the journey, booking, guidance, check in/out, pricing and billing

The feeling of freedom will be guaranteed by the flexibility and the reliability of the tool [25].

3.3 Future Internet solutions helping to solve city transport problems

The Future Internet will provide enabling technologies to allow:

• Seamless connectivity anytime and anywhere of passenger with the Instant Mobility network and resources.

• Real-time transmission of measured data, real-time processing of this data and real-time distribution of processed data.

• Secure data transfer for payment and access control services.

• Scalability of the system, allowing a growing number of users to take benefits from cloud resources to manage increasing needs in computing capabilities.

The Future Internet solution will address the above problems by providing a machine-to-machine interaction between passengers and drivers. Sharing information from travellers about their planned and ongoing trips can enable the driver to share his vehicle trip as well as system wide optimization for travel time, costs or pollution. The provision of information sharing could be based on driver's vehicle on board device using mobile technology to interact with multi-modal planner in the cloud.

Travellers will be able to take important decisions by having access to relevant data, such as: comparing travels times with different transport modes including ride sharing, knowing in advance the availability of a ride share, etc.

3.4 Crowdsourcing services

In a world where reaching and connecting with consumers gets increasingly complex every day, Internet users are introducing a new trend for searching and retrieving information which is named "crowdsourcing".

Crowdsourcing is a distributed problem-solving and production process that involves outsourcing tasks to a network of people, known as the crowd. This process can occur both online and offline [26]. In the case of Transport and Mobility services, crowdsourcing will be supported by all transport resources: vehicles, drivers, travellers, and road infrastructures especially using Internet of Things technologies based on sensors and actuators and all ICT technologies required for connectivity.

The required interoperability between all professional actors is the first pillar of the expected collective intelligence to complete business-related tasks that companies could usually perform but deliver only pieces of information to transport users.

The idea of requesting from travellers and drivers inputs on their journey is not really new but the way these services are developed today, can provide only from time to time few information since people are more consumers than producers of information, especially for traffic issues. If people are involved in multimedia content production, they will be providing some data that are also relevant for transport and mobility services, following strictly privacy rules of their usage.

4 ONLINE TRAFFIC AND INFRASTRUCTURE MANAGEMENT

The future Internet and the technologies listed in the previous sections shall enable the development and deployment of the myriad of traffic control systems and services to assist the people and goods mobility in the cities. In the domain of traffic and infrastructure management, the following systems and services shall emerge [25, 27]:

4.1 Traffic control operations on intersections and along the city streets

These services shall be hosted in the Internet in cloud resident secure virtual traffic controllers within virtual traffic centre. Local traffic control systems on the ground supporting intersections infrastructure shall have the task of providing safety controls in case that the communication with cloud servers is not available, as well as to provide interface to traffic lights. Virtual components of the traffic controllers in the cloud and data shall be accessible from anywhere to authorised personnel, while local control units on the ground guarantee reliability of the system in case any failure in communication with cloud controllers occurs.

Important for implementation of described traffic controller architecture are wired and wireless connectivity, deployment of the sensors and actuators, computational resources in the cloud as virtual data centres where the virtual traffic controllers shall be implemented using the model “platform as a service” (PaaS).

4.2 Demand management adapted to traffic condition

The service shall be based on real-time data from location services available on vehicle platforms as well as within smart devices of pedestrians, in conjunction with complex event processing of the virtual traffic controllers.

City wide traffic demand shall be managed through adaptive physical control and pricing for the service enabled by performing online services. Targeted flows shall be achieved through variation of permitted vehicle flows and adaptive pricing.

For the stationary part of city traffic the interplay of Internet of things, location services and notification services shall provide online services for controlling availability of parking spaces with driver guidance to the free parking location to balance demand across available parking facilities.

To fully implement described model of city intersections traffic control in the cloud, the sensor networks for road and intersections infrastructures shall be required including streaming video cameras, proximity and presence sensors etc. as well as vehicles equipped with sensors in (V2I) configurations.

New control algorithms with advance traffic control shall be required to manage in real-time traffic lights depending on traffic status using situational analysis.

In order to obtain full information on the statuses of traffic lights the actuators controlling the traffic lights on the crossroads will be required to have two-way communication.

To implement the concept of virtual paths along fixed traffic paths in order to enable priority for certain vehicles (police, fire, ambulance, etc), mobile networks based on (GPRS, EDGE, HSPA) shall be required to support this service.

Connectivity to all vehicles (V2I) and (V2V) shall also be required to take into account all traffic in real-time.

To manage dynamically green waves along the city streets network, vehicles as sensors shall be required together with new algorithms executed within virtual traffic controllers in the cloud. Comparing with existing situation with static green waves without speed recommendations to drivers, this shall significantly increase the throughput capacities through cities main traffic corridors.

To achieve the desired dynamically changeable green waves, more on-vehicle sensors shall be required to monitor the vehicle status. Additionally, profiles shall have to be defined for each vehicle to identify statistical and individual routes and organize green waves.

Today’s street intersections are unaware of approaching traffic and are therefore unable to determine at which times change of the traffic lights can be best organized as to minimize delay of traffic flow on all intersection approaches.

Vehicles as sensors and sensors on road infrastructure shall be required to enable this dynamic change in traffic lights sequence. Public data available from social networks through crowdsourcing shall provide common view on all vehicles participating at specific intersections and drivelines.

New algorithms and computational resources shall be required to extract relevant information from social networks and manage traffic in real-time.

In order to achieve city area wide optimization strategies in traffic regulation from cloud based traffic controllers, new models and algorithms shall be introduced to manage different types of data. Connectivity for vehicles and infrastructure is the framework to collect all relevant data and process it in real-time.

For this purpose common public data system shall be useful and this is the way how this optimization should be implemented in future smart traffic networks.

New, events oriented models, will support real-time approach and peer-to-peer optimization mechanisms. Local optimization will influence neighbouring areas of traffic but shall not create overall optimal solution on the city level.

Traffic-adaptive demand management shall be based on statistical view created from public data collected with anonymous mechanisms, and on real-time data provided by vehicles as sensors and sensors from road infrastructure.

All this data gathered in real-time shall enable traffic-adaptive demand management which should replace optimal calculations done with static data as performed today.

4.3 Cooperative traffic lights

Traffic lights control built on ad-hoc networks shall be created in the cloud between the clusters of vehicles and traffic management infrastructure.

This ability to create ad-hoc cooperative network of traffic controllers, shall offer drivers a recommended speed of driving to avoid stopping at next intersection and long queuing, and adapting traffic signal sequence to the real demand, and in real time.

The envisaged functionality of cooperative traffic lights control shall be based on broadband wired and wireless connectivity of sensors and actuators, computational resources in virtual servers in cloud using IPV6 addressing of all smart devices and hardware infrastructure and with notification services provided as multicast as well as point-to point communication, making use of built-in GPS devices and location services.

4.4 City-wide traffic optimization strategies

These strategies shall be possible to implement thanks to the accuracy of gathered and exchanged data, large-scale data analysis in real-time through data mining on these data servers, and complex event processing.

To effectively process this huge amount of data on vehicle and pedestrian movement and on traffic control, measurements and predictions are mashed up in a comprehensive optimization process. Self-learning strategies shall be applied to achieve least carbon emissions (green score of the system), least delay, etc. [27].

4.5 Demand-adaptive parking management

Parking management in future smart cities shall be achieved through interoperability of parking owners publishing availability data on web sites and drivers what shall provide a global overview of parking locations availability. To identify free places in parking areas in real-time, presence (occupational) sensors shall be required to clearly identify free places within parking locations. Real-time guidance of driver to free parking location and assisted parking shall be available for outdoor as well as indoor parking location, owing to implementation of always-on connectivity.

5 COLLECTIVE TRANSPORT IN SMART CITIES

Collective transportation means that shall offer mobility of the citizens of future smart cities will be supported with the range of services based on the mentioned Internet technologies and Internet of Things, among others:

5.1 Demand-adaptive coordination service

This service shall be based on interoperability of service providers, who will provide online service capable to receive passenger's request and offer him optimised transport for his multimodal movement (e.g. passenger is using different public transportation means , taxis, dial-a-ride, special transport services, etc.).

The service shall be based on the model of social network including local profiles of passengers and real-time data provided by sensors embedded into nomadic devices, taking benefits of real-time data as well as historical data.

Processing all this data with new class of algorithms and real-time adaptation of itineraries will improve the effectiveness of public transport.

Based on collected real-time data, in case of traffic congestion or disruption, multimodal transport solutions will be proposed to passengers automatically, to avoid congestions and passengers delays in collective transport.

On-board devices and real-time monitoring of all collective transports will provide real-time statuses.

5.2 Mobile passenger data collection

This activity will be based on deployment of all kind of location and other vehicle sensors on collective transport(buses, tramways, metro, etc) stops, with passenger mobile devices providing location and destination information. In combination with route and service information this service shall enable real-time operational optimisation.

Sensors embedded into infrastructure as well as mobile devices acting as sensors will provide an accurate information of passengers distribution at public transport stops.

Electronic nomadic devices shall include several types of sensors. New road and traffic infrastructures will enable real-time collection of data and events based on local profiles of passengers.

Based on these data, applications on central servers in cloud shall be able to capture anonymously destinations of ongoing passengers and vehicles and in case of sudden congestion and traffic disruption, be able to advise drivers and passengers how to proceed to avoid these congestions and disruptions.

5.3 Flexible schedule adaptation

Will be based on computational resources available in cloud and real-time vehicle monitoring. Traffic operator shall use online passenger demand information to adapt service route and timetable, and to inform passengers of service modification.

New models will bring more granularities into timetables and monitor alternative routes along the time shifts. Based on real-time location tracking, real-time timetables will be available.

Real-time tracking of collective transport vehicles as well as on-board passengers will provide a public knowledge of expected delays for passengers waiting at stops. Real-time tracking of all vehicles will provide traffic knowledge to avoid traffic congestion and define priorities for some transportation means. Based on existing connectivity of other vehicles, alternative multimodal solutions will be proposed to passengers stacked in public transport.

5.4 Adaptive priority of collective transport

This service will be based on real-time and online traffic modelling in traffic controllers, and shall adapt traffic lights timing to offer green lights to buses and other collective city transportation means, providing speed recommendation to vehicle drivers.

For this functionality it shall also be needed (via sensors and vehicle to infrastructure (V2I) connectivity means), information about other vehicles for areas where no dedicated collective transport lanes are available.

Interoperability between traffic tracking systems is also required when several companies are operating in the same area.

5.5 Ticketless fare charging

Fare charging will be implemented using some existing technologies like RFID, and new one like NFC (near field communication introduced by Google on his smart phones) and interoperability among devices and vehicles. Public transport operators shall use Internet to collect fares via user mobile devices (smart phones with NFC reader) and to connect to mobile ticket inspectors. Electronic ticket (e-tickets) payment will be combined with passenger's other mobility services and added to monthly account. Internet shall also be used for inter-operator payment clearing.

Digital payment shall need new NFC technology and interoperability between providers: transport, services, banks etc besides existing one introduced by Google [28]. New business models will emerge based on the impact on the value chain.

Always-on connectivity is also required (radio and wired) to exchange and validate in real-time payment process.

New business models requiring accuracy of all transport data and traceability of how people are travelling will emerge, especially to include incentive mechanisms (bundle of incentive prices that shall depend on time of travel, environmental quality of transport mean, type of transport, etc.)

5.6 Security monitoring of driver and passenger

Monitoring for security reasons shall be possible via mobile broadband always–on connectivity and available cloud based computational and data storage resources. In possible scenario of the service, real-time or previously reordered and stored video of vehicle interior is sent wirelessly to web service that automatically identifies problems (with driver or passenger) and alerts security guards.

On-board authentication systems are connected to third parties in real-time. Vehicles embedded sensors and passengers personal devices shall be independent parts of the same collaborative security system.

6 SUMMARY

The paper outlines the way we can expect how to use Future Internet and related technologies for innovative application scenarios to solve mobility of people and goods in future smart and green cities. Firstly, presented and summarised are some observations and guidelines on how these problems could be solved on the range of cloud hosted computer services that shall evolve in the next years. Defined are and outlined the main technical and functional characteristics of the solutions for intelligent traffic control and management systems and services in future cities.

As underlined in the paper, It will be feasible in the next few years to build and launch services based on people as nomadic sensors, using smart phones as smart sensor devices. Citizens will be part of the same social networks of city travellers as producers of static and real-time data relevant for public transport services, but without strong security and privacy warranties for data put on public networks.

Judging by the vehicle development cycle, it is unrealistic to expect a substantial introduction of "vehicle as sensors" devices in all V2X varieties, except if something, like it was GPS navigation system, suddenly appears on the market for post production installation.

In the segment of truck, professional fleet vehicles and high end personal cars, since connectivity is always important, the type of described services based on-vehicle sensors data, shall appear earlier than for general passenger cars.

Sensors for road infrastructure based on existing and envisaged technologies with short range mobile devices require lots of investment. The emerging market of Machine-to-Machine using SIM and MIM cards is used for transport systems as well in order to decrease maintenance cost and cover larger areas in city road infrastructure [29].

The ITS solutions based on the four pillars : Internet of Networks, Internet of People, Internet of Things and cloud computing, should not be considered all inclusive and exhaustive set of technologies, but promise to solve a vision of mobility of people and goods in the future smart cities.

Based on these resources, future Internet in smart and green cities shall interconnect fixed and mobile transport infrastructure, turning it into flexible, dynamic online services; mobility and transportation actors shall become partners of the infrastructure, transport infrastructure shall adapt to the users.

7 REFERENCE

[1] EU FP7 Project: FUTURE INTERNET PPP, INSTANT MOBILITY; Stakeholder workshop, 28-10 2011, Brussels, Belgium

[2] Samad T. and Annaswamy A.M. (eds.) : The Impact of Control Technology, 2011 (available at www.ieeecss.org.)

[3] Bragagnini Andrea , Dubus Nathalie, Peña Cristina : A Future Internet Vision , EU FP 7 Project, Future Internet PPP , 2012.

[4] Smith Ian G. (Editor): The Internet of Things, 2012 new Horizons, published by Halifax, UK, 2012

[5] GS1 UK : EPCglobal RFID standards , Staple Court, 11 Staple Inn Buildings, London WC1V 7QH, 2011

[6] Culler David E. , Jonathan Hui : 6LoWPLAN Tutorial, IP on IEEE 802.15.4 low-power wireless networks, Arch Rock Corporation 2011.

[7] US Department of Transportation, The Intelligent Transportation systems (ITS) Joint Program Office: "Intelligent Transportation systems (ITS) Standards program Stratigc Plan for 2011-2014" , April 2011

[8] IBM web site : IBM cloud computing: Rethink IT. Reinvent business. (http://www.ibm.com/cloud-computing/us/en/) – August 2012

[9] IBM Global Technology Services : „"Strategies for assesing cloud security" , November 2010

[10] Open IMS Core's Homepage (http://www.openimscore.org/) - August 2012

[11] Esfandyari Jay, Mascotto Massimo, Gang Xu : " MEMS pressure sensors in pedestrain navigation" Sensors , December 2010

[12] Samsung Galaxy Note II specifications (http://www.samsung.com/global/microsite/galaxynote/note2/spec.html?type=find , – August 2012

[13] Padua David (Ed.) : Encyclopedia of parallel computing, Springer 2011

[14] Woerndl Wolfgang : "Authorization of user profile access in identity management" , IADIS International Conference WWW/Internet 2004

[15] Zhang Longhua, Ahn Gail-joon, and Chu Bei-tseng : " A Rule-Based Framework for Role-Based Delegation and Revocation", ACM Transactions on Information and System Security, Vol. 6, No. 3, August 2003

[16] European Commission : " Eurobarometer – Future of transport – analytical report, March 2011

[17]Market research.com web site (http://www.marketresearch.com/Berg-Insight-v2702/Personal-Navigation-Devices-Edition-2878597/) – August 2012

[18] Wikango smart driving model 700 http://www.wikango.com/support/fr/w700/GuideW700.pdf - August 2012-09-04

[19] Information on web site (http://www.fixmytransport.com/) – August 2012

[20] Information on web site (http://www.checkmymetro.com/ecp/) – August 2012

[21] Information on web site http://www.metroeclaireur.com/ – August 2012

[22] Google prediction API (https://developers.google.com/prediction) – August 2012

[23] Smartphone predicts traffic jams (http://news.discovery.com/tech/smartphone-predicts-traffic-jams-110413.html) - August 2012

[24] IBM Traffic Prediction Tool (http://www.ibm.com/smarterplanet/us/en/traffic_congestion/nextsteps/solution/) August 2012

[25] EU FP 7 Project : Future Internet PPP, Stakeholder Workshop : "A vision of Internet- enabled mobility" , October 2011, Brussels, Belgium

[26] Public transport croudsourcing on web site (http://www.crowdsourcing.org/navigate-search?q=public%20transport%20crowdsourcing) , August 2012

[27] IBM Smarter City Solutions on Cloud , IBM Global Services white paper, 2011

[28] Article: Google unveils cloud-based revamp of wallet but keeps NFC technology (web site http://nfctimes.com/news/google-unveils-cloud-based-revamp-wallet-keeps-nfc-technology) - August 2012

[29] Article : M2M Service Enablement- MIM Services Cinteron a Gemalto Company, July 2012

Intermodal (RE) Development between Green Logistic and Intelligence Environment Green Strategy for The New Intermodal Shape in case of Sagrera, Sant Marti and Verneda – Barcelona

V.Savcic[1]
[1] Architectural Projects Department / ETSAB , Polytechnic University of Catalonia / UPC
Barcelona, Spain

Abstract
The paper is analyzing intermodal shape as a www product of actual and future strategic development based on green logistics and intelligence environment issues in case of the new intermodal node in Barcelona Metropolitan Area. Infrastructural objects, transportation networks and technical greed are functional motherboard in actual mobility process; new intermodal shape is one of the main pivots in design and spatial mapping. This new urban acupuncture - intermodal nodes with particular shape concepts are transforming native surroundings applying sustainable, green and intelligent layout as a dominant gap in design and urban consummation.

Keywords:
The Shape, Mobility, Green logistic, intermodal node, Smart greed Environment

1 INTRODUCTION

Intermodal sustainable practice strategy takes important role in global green design politics and urban (re) development on metropolitan scale. Inter-change areas, traditionally introduced as infrastructural backup and necessary service level today are spatial polygon for last generation logistics and intelligent environments inputs.
New urban focuses and global landscape of nodes, streams and mega-structures are into green smart concepts with sustainable shape inputs. If the urban infrastructure is updated it is possible to describe new shape models of inter-change areas, model of green environment mobility concepts?
Sagrera – Sant Marti – Verneda intermodal area in Barcelona is part of the integral mobility project for new main intermodal terminal and connection concept between several mobility pivots on city scale level. Spatial development and particular shape solutions are presented as possible mobility- innovative shape concepts applied in real for sustainable logistics and green intelligence environment implementation on www level

2 SAGRERA INTEGRAL PROJECTS / MACRO SCOPE / SUSTAINABLE ENVIRONMENT AND BARCELONA NEW URBAN GEOGRAPHY

La Sagrera, new intermodal axis of Barcelona Metropolitan area is generating Spatial (Re) Development of actual metropolitan urban structure, incorporating intelligent environment and green strategy as main issues in new intermodal evolution process. This green efficiency urban zipper is moving intermodal gravity pivot from west to east part of the city. Barcelona Sants mobility node will be replaced with new one Principal metropolitan Hub in Sagrera intermodal terminal.

(a) (b)

Figure 1:
(a)Barcelona MA speed train concept
(b) West and east MA intermodal node

This integral concept will be the strongest inside city green corridor, green line will be longest and most dominant urban green connector starting from Triniti Park until de coast and beach zone.

Figure 2: City Green Zipper Corridor, BCN

La Sagrera is intelligent environment integral concept and multi layer project, new sustainable goal on metropolitan scale level. With the live and dynamic issues this concept offer compact configured, high density areas with several activities and user groups mixtures. Green logistic and intelligence environment equipments and element are branding new intermodal Shape. The motherboard of spatial concept is lineal park (40ha) which is transforming old barriers in the active space (open space concept:

streets, squares and green areas; constructed sectors). The project is paradigm for multilayer interaction between the city and infrastructure, ground and underground. Main gap in the concept is the new Terminal – station of the stations. This main node is gather several upper level satellite nodes working us sustainable network and producing functional intermodal matrix with particular shape goals.
This new intermodal shape form, models and variants, posted on sustainable and intelligence development are growing in particular metropolitan brands and possible export exams.

3 SAGRERA, SANT MARTI AND VERNEDA / MICRO SCOPE / GREEN LOGISTIC AND URBAN FOCUS

3.1. Sagrera Terminal, Urban Focus in general

Sagrera Terminal is main intermodal subject in Integral project concept and inter change pivot on metropolitan scale. integration of Sager station will transform city public transport network in the same way as it did it with partial road corridors(lateral speed connection transversals) pivot from west side will be moved on the east part of urban structure, and together with peripheral passes (Rondas) will create a dominant transport Matrix. New guide line, with central penetration try city structure will be adapted faster and stronger connection with two most dominant units of Hospitalet and Badalona, such us and most potential connection with interior part of metropolitan structure (underground link via tunnel Sants-Sagrera, this link will redevelop and connection under the Arago street and make it more efficient for city train lines). Collocation and cross section of strong speed line transversal try central city structure will make changes in habitual transport system making a public transport network more efficiency for several transport modes (new city train lines, new subway lines corridors). On regional level:Sagrera Terminal in project is a pivot in interprovincial speed train connection (LLeida- Tarragona – Barcelona- Girona) which will put on Catalonian transport system as rounded subject in national transport strategy development. On international – regional level, Sagrera terminal is a motherboard for Barlyon Region (Barcelona – Lyon), as a basic point in interconnection of Spanish and French speed train networking, in this context Sagrera terminal will be switch on as an important pivot in the biggest European integral system of speed train greed
Design concept is multilayer – reduced plot up and short communications links. The dominant part is subterranean structure of 4 levels plus roof (green area) which is divided on fast train hall, fast train platform, bus station, city train and subway hall, city train and subway platforms and parking area. (Terminal will serve five connections for speed train system, four for city train, two plus two for subway infrastructure and almost 3000 parking's).
The main space is Intermodal cluster, inter-change hall (superficies of 320 000 m2 will be charged with huge commercial area).
The project is active urban connector between two neighborhoods, Sagrera and Sant Martin, historically separated by railway infrastructure. Functionally this spatial zipper is the station of the stations, intermodal hub with several sub modes and public transport network us a main spatial and functional issue. Sagrada terminal and surrounding intermodal zone on Sagrera – Sant Marti – Verneda will incorporate intelligence environment issues and green strategy concepts in direct multilevel user experiences, from inter change travelers to daily neighborhood actors. This sustainable strategies and contemporary concept of green urban intelligence will produce particular formal solutions and shape concepts atypical for infrastructural objects and its implementation into native structure. Terminal building us underground structure is integrated in lineal park concept and green roof cover of intermodal halls areas is treated like integral park element. To improve efficient mobility on reduced plot up main inter change areas are intermodal underground halls, one for city train platforms – Sant Marti side entrance and one for speed train platforms – Sagrera side entrance.
Central heating and ventilation systems is from the existing one for city level (Forum) and cooling system is from sea water chillers pools (22@ concept). Water efficiency is supported with new deposit for atmospheric water and its re use. System is managed by the last generation of Electrical and telecommunication networks. Waste management is provided with pneumatic system and reduced transport circulation.

3.2 Sagrera Intermodal zone, Micro Scope boundaries

Sagrera intermodal zone is inter change area with direct intermodal shape application. In structural concept intermodal zone contain of vital corpus area – area with green logistic and intelligence efficiency dominants, terminal connection area and new shape system area.

Figure 3: Sagrera Intermodal Zone, BCN

Micro scope boundaries are in general strong communication vectors which are determinate the first field of intermodal shape influence, around terminal hub area and global check-in points in inter change practice.
Scope porosity can be transmit on different levels depending from surrounding native structure and power of intermodal shape influence

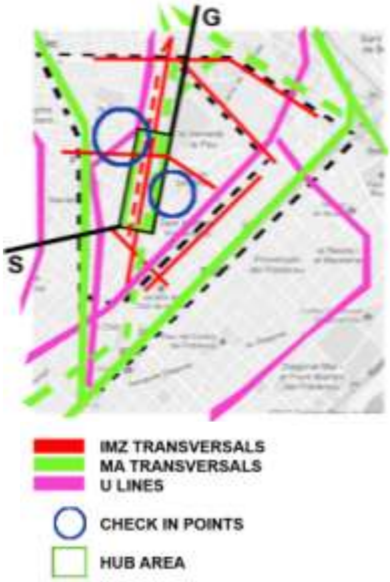


Figure 4: Sagrera Intermodal Transversal, BCN

Mobility infrastructural back up for Sagrera intermodal zone and actual shape models is based on terminal infrastructural network, main scope vector and service zone areas. This infrastructural object are technically supporting modal inter change, in capacity and quality of fast connection and high fluency.

Figure 5: Sagrera Infrastructural Interface, BCN

Volumetric concept of Sagrera intermodal zone is following structural changes, managing attractive central area of future vital corpus area with new beacons and interpolated traditional texture of blocks on the border areas. Important for shape models is actual and future open space area and its relevant design potential. Future volumetric diagram will get partially higher density in the central part of green logistic zone and less volumetric gaps with low index value.

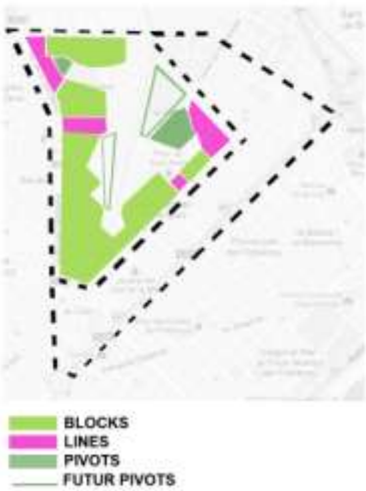


Figure 6: Volumetric concept, Sagrera, BCN

1.3 Micro Scope Shape Models

Shape models in case of Sagrera, Sant Marti and Verneda are particular experiences about intermodal shape concept and its manifest and variety with possible conclusions of www applications in the future intermodal practice. Correlations between interchange process, sustainable concepts and high technology issues mixed with native structure and actual architectural brands make strong formal expression and field for high potential flux.

Models, with basic shape elements and correlations between are managed via several interface levels and in case of each one: structural, formal, urban or infrastructural dominants, unique shape concept get variants and multi-applicable solutions.

Interface Model identification

Interface shape models are posted on - in place – mode, with strong structural back up and intermodal zone inter change mehanism. Relation and patch between Structural elements: terminal, vital corpus and borderline are introducing varies shape concepts, from total or partial elements integration throe shape models with element independency and no switching. On this inter-structural diversion with multilayer or multi-interface crossing apply result can be several interface shape models, less or more consistent for www application.

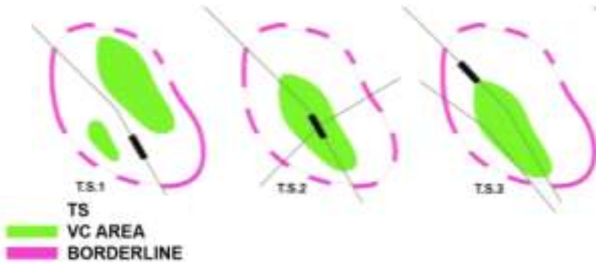


Figure 7: Structural Interface Models TS, Sagrera, BCN

In the intermodal greed where the main node is correlated with one or several satellite nodes structural interface will be upgraded with network elements issues and Metropolitan Concept of inter-mobility. New interpolations as native structure adaptation or wasted area activation will enter as new structural subjects and formal gaps for appropriate shape expression. It is possible to research shape elements in Networking, Beacon or System concept of intermodal node greed.

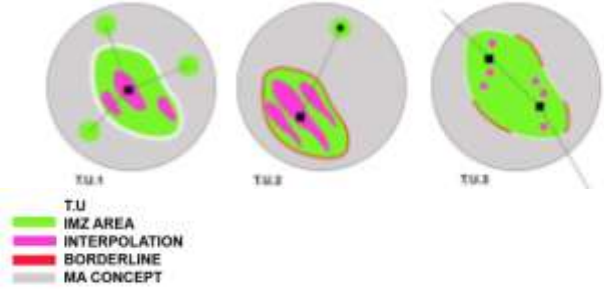


Figure 8: Urban Interface Models TU, Sagrera, BCN

Volumetric data update on appropriate interface model will download basic formal interface model. This shape model and its varieties show us volumetric correlations via typical cross sections on the strong intermodal transversals. Elementary spatial distribution and volumetric values are base and potential of this model for upper level intermodal shape classification.

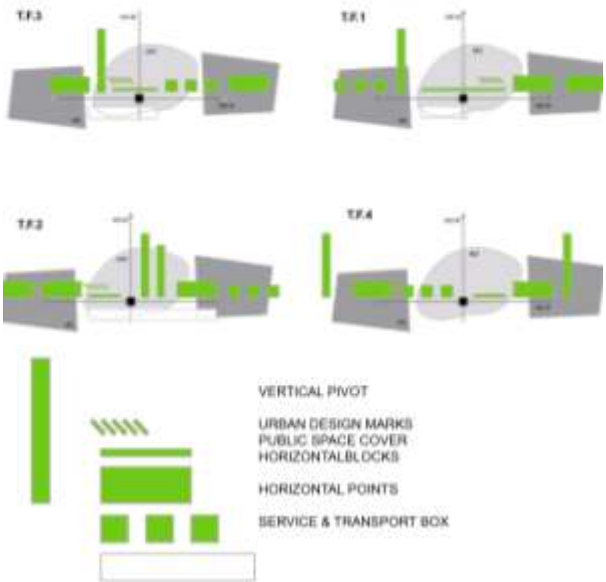


Figure 9: Formal Interface Models TF, Sagrera, BCN

Elements Model identification

Basic intermodal shape elements are primary formal concepts and solutions for needs in intermodal exchange practice. Relaxed from - in place – dependence context and focused on green strategies and intelligent environment particularly shape elements are in the main case last technology applications and sustainable recompilations of traditional base.

IT background and LEED Standard are base for Sagrera, Sant Marti and Verneda intermodal elements development. All intermodal shape strategy in case of Barcelona east zipper hub is getting post contemporary connotation, with support on local environment experience and IT technology advantages.

Concept of intermodality and elements inside can be simplified on urban fragmentation between start, distance, crossings, preliminary stops and goals. In intermodal element shape analyze we are focused on corridors, retentions and superficies.

The shape of corridors, lineal vectors on interchange routs is particular intermodal issue in way that spatially and designing need to support and manage multi-change politic and in the same time offer strong self identity. This spatial links are functionally and easy readable but need to glorify original and unique design catch for several transit user groups. Basic segmentation is on pedestrian, transport and multi routs corridors. Pedestrian links are main goal in investigation for important contact with primary user in inter-change. Transport corridors are from secondary importance, the accent is on the alternative and new concept corridors like a public biking or car-pools or special service corridors. Multi corridors offer high level of interrelations and modes in link organization, several design and shape concepts.

Superficies and design in 2d have importance for intermodal shape concept. This shape mode in horizontal or vertical marks general forms and basic formal sprawl in urban intermodal change areas. In case of Navigations this design options can be completely opposite in technical or strategy way, from the Screening and Screen Superficies concept throe traditional plots up texture concepts.

Superficies as a separators and limits in interchange practice will be introduced as Bio link Diagrams, lines and fronts, horizontal and vertical plot ups (vegetation and water). Fragmentation and shape structurating concept in Sagrera can be provided by Cover structures on the main links (shadows and forms in intermodal shaping).

Recharge systems are superficies with important design challenge in interchange practice. Functional complexity and design inputs are difficult opposites in this type of shaping (garbage-of terminal areas and Wi Fi - Wlan public areas).

Figure 10: Screening, Sagrera, BCN

(a) (b)

Figure 11:

(a)Green Roof Concept, Sagrera Terminal

(b) Rambla Concept, Biolinks

Transit and crossing areas in intermodal zones are very dynamic and changeable spatial and formal entities. Most important about design and shape qualities of these areas is facility to permit several different corridors and link connections crossing and big capacity oscillations, from high to low densities. Intermodal shape in retention zone need to manage this multi-directional interchange.

When the crossing is one level we have flat retentions – all links crossing and retention shape is sprawling on horizontal. When the intersection between links is on the several levels we get multi retention, transit shape is growing from sprawling and horizontal system into vertical crossings concept.

(a) (b)

Figure 12:

(a)Wi Fi area symbol, BCN

(b) BCN public Wi Fi Totem

4 SUMMARY / GREEN LOGISTIC AND GLOBAL LANDSCAPE OF NUDES – WWW SHAPE

Is it brave conclusion that Intermodal shape models, interface and elements from Sagrera, Sant Marti and Verneda have capacity to transmite some global applicable values about mobility shape in contemporary metropolitan area? What are criteria for constants and variables in some general composite model applicable on www level? Is it intermodal shape positive value in green logistic practice evolution and does intelligence mean practical or real?

Conclusion and expectative about intermodal shape can be in general positive with idea that new urban acupuncture – landscape of mobility nudes is transforming actual metropolitan reality. This transformation is going above green development and intelligence environment strategy and is multi directional on contemporary urban structure. In that context Intermodal shape is important fee back on actual urban and architectural reality.

In case of Barcelona intermodal shape is one of the unique actual vibrant inputs and one of the most important gaps for future development of this high developed but in decadence metropolitan area .

Is it early to discus about intermodal shape and next brand made in Barcelona www?

REFERENCES

[1] Abruzzo, E., Duval A., 2004. 306090 08: Shifting Infrastructures, Princeton Arch Press

[2] Blow, J.C., 2005. Transport Terminals and Modal interchange, Planning and Design, Elsevier

[3] Busquets, J., 2005. Barcelona- The Urban evolution of a Compact city, Harvard University Graduate School of Design

[4] Clementi, A., 1996. infrastrutturee e Piani Urbanistici, Facolta di Architettura di Pescara

[5] Hunk, D., Ohland, G., 2005. The New Transit town: Best practices in transit-oriented development. Island Press UK

[6] htpp: // www.linkforum.eu / index.phtml?IDI-984 [08.07.2012]

Assessing the Overall Life Cycle Impact of Home Energy Management Systems

S.S. van Dam[1], J.C. Buiter[2], C.A. Bakker[2]
[1]Sustainable Housing Transformation, Faculty of Architecture, Delft University of Technology, Delft, The Netherlands
[1]Design for Sustainability, Faculty of Industrial Design Engineering, Delft University of Technology, Delft, The Netherlands

Abstract
An ever-increasing body of research explores the effectiveness of Home Energy Management systems (HEMS) in achieving energy savings. To date, however, the overall life cycle impact of the HEMS itself has not been taken into account. Thus, no assessment has been made whether the amount of energy saved (e_{saved}) outweighs the energy needed for production, use and disposal ($e_{invested}$). To determine whether e_{saved}>$e_{invested}$, a lifecycle assessment was conducted comparing three HEMS in six usage scenarios. The results show that the impact is dependent on the type of HEMS, and that the benefits do not always outweigh the (environmental) costs.

Keywords:
Home energy management system (HEMS), life cycle assessment (LCA), feedback, household energy consumption, smart meter

1 INTRODUCTION

Home energy management systems (HEMS) are defined as intermediary devices that can visualize, monitor and/or manage domestic gas and/or electricity consumption [1]. Their main purpose is to give users direct and accessible insight into their energy consumption. This makes them different from smart meters, which are predominantly intended for automatic two-way communication of energy data between the gas or electricity supplier and homes. Smart meters generally need HEMS to give users the intended feedback and insight. [2, 3]

HEMS are being given increasing attention both in academia and in commercial enterprises and are much advertised and promoted as 'high potentials' for domestic energy savings. Studies have indeed reported positive results up to 10% or even 20% savings, at least in the short term [4, 5], but in the mid to long-term studies it was found that HEMS are less effective [1, 6, 7].

While savings of 5 to 15% [8] in electricity or gas consumption can sound impressive, this is not a complete picture for a number of reasons. Savings are regularly not achieved on the total energy consumption of a home but rather a part of it. So, for example, savings were only achieved for the gas or electricity consumption of one appliance [5, 9], or for overall electricity consumption but not for heating or gas [1] or vise versa [6]. Currently, there is little evidence to guarantee that these same savings can be achieved for other appliances or types of energy.

A second reason why the stated savings present an incomplete picture is that studies tend to report on the resulting direct energy reductions within the home. In such studies, the achieved savings are usually calculated in the following manner: a number of households are selected, pre-trial baseline consumption measurements are made and/or control group(s) are selected, the HEMS are installed and the meters read (or the consumption data is tracked), and, after a specified period of time, the meters are read again and the HEMS uninstalled. The two (or more) readings are subtracted from each other, possibly corrected for seasonal influences and compared to the baseline or control group measurement. This is an important assessment. However, it should not be the last or only. In the strictest sense of the word, these 'savings' are not all savings. Energy is needed to produce, use and dispose of the HEMS. HEMS need hardware to measure the consumption of appliances and/or energy types. More hardware will likely mean that more energy is needed to produce and/or run the HEMS. When this energy is subtracted, the net energy savings become apparent. This is a more accurate depiction of the effectiveness of HEMS.

A third reason is that the savings are calculated over a limited period of time. However, the period after the intervention has ended presents a number of uncertainties. Care should be taken when extrapolating the savings to the period after the intervention. There is evidence that the achieved savings decrease over time [1, 6], and that not everyone manages to save with a HEMS [1]. Additionally, there is risk that HEMS become obsolete before their technical lifespan has ended [4]. Taking these factors into consideration, a holistic approach becomes essential. Only then can it be assessed if the benefits outweigh the costs. Therefore a holistic view is advocated by taking the overall life cycle impact of the HEMS itself into account. This is currently not a standard approach. Only one study could be found where the overall life cycle impact was analyzed and reported. This was for a HEMS intended to conserve water [10].

2 OBJECTIVE

This paper aims to give a more complete picture of the overall effectiveness of HEMS. Consideration should be given to the overall life cycle impact of HEMS and not only to the direct energy savings that can be achieved. In other words, a trade-off needs to be made between the energy needed for production, use and disposal of the device versus the amount of energy saved within the home by using it. When the savings achieved through

HEMS are only sustained for a short period, it is hard to break even with the amount of energy invested.

Effectiveness was defined by van Dam et al.,[1] as the extent to which users can maintain significant energy savings over prolonged periods (>4 months). This definition is not sufficient for this article as the meaning of the words 'energy savings' need to be more specifically defined. A distinction needs to be made between *net*, *direct* and *indirect* energy savings. In literature implementing HEMS, 'energy savings' usually refer to *direct* energy savings on gas and/or electricity, depending on the type of energy the HEMS targets. Spillover effects to other forms of energy or savings on *indirect* energy consumption (i.e. energy embedded in the production, transportation and disposal of consumer goods such as fruit, ready-made meals, etc.) are difficult to measure and attribute to a particular intervention. As such, they are less studied, with a few exceptions [11]. Within this article, the focus is on positive *net* energy savings where $e_{saved} > e_{invested}$. So, within the stated definition of effectiveness, the words 'energy savings' refer to a positive outcome of the equation: *Direct* energy savings through use of the HEMS minus the energy invested in the HEMS itself.

The objectives of this case study were firstly to assess whether the environmental benefits of HEMS outweigh the environmental costs and in doing so effectively contribute to household energy savings. As this is time-dependent an additional objective is to determine after what time a breakeven point can be achieved where $e_{invested}=e_{saved}$ and whether it is realistic that this will be achieved during the economic and technical lifespan of a HEMS. The final objective is to evaluate whether the HEMS are economically viable for households and what the payback is.

Based on previously conducted life cycle assessment studies (LCAs), and HEMS usage tests from previous studies, we had certain expectations. Because 'simple' HEMS (e.g., HEMS with few parts or with small displays rather than LCD (touch) screens) are relatively low-tech products, we thought that these would have a positive net energy balance. In contrast, as our experience from running trials with HEMS showed that the energy consumption of more complex HEMS was not optimal and that duplicate peripheral devices were sometimes implemented as part of the setup of the HEMS, we thought it highly questionable that the net energy savings would be positive in these cases.

3 SETUP AND METHOD

To assess the impact of the production, use and disposal of HEMS on the overall effectiveness of HEMS, three HEMS were analyzed using cumulative energy demand (CED) and eco-costs indicators. For the use phase of the HEMS, a number of scenarios were developed for the potential energy savings. The three HEMS were chosen due to their diverse nature and as a representation of the different types of HEMS available on the market. The HEMS were an energy monitor, a multifunctional HEMS and an energy manager.

3.1 Description of the three HEMS

The energy monitor is a small, straightforward, dedicated device that gives real-time feedback on overall electricity consumption within the home. Figure 1 gives a schematic visualization of the setup of the energy monitor.

The energy monitor consists of a sensor, a transmitting unit, and a display. The sensor and transmitting unit are attached to the electricity meter and are battery powered by 2 AA batteries. The transmitting unit sends a radio signal to the display, which is plugged into a socket. The display unit uses 1W and the batteries in the transmitting unit last six to twelve months depending on the frequency with which the signal is transmitted. There is an accompanying website with a step-by-step plan and advice for saving energy.

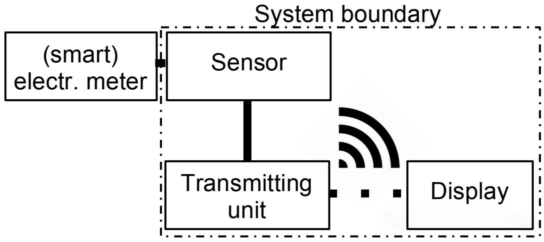


Figure 1: Schematic visualization of the setup of the energy monitor.

The second HEMS, the multifunctional HEMS, gives historical, and in certain configurations real-time, feedback on overall gas and electricity consumption. The device, a touch-screen, doubles as a programmable thermostat and can also provide up-to-date weather and traffic information. Figure 2 gives a schematic visualization of the setup of the energy monitor.

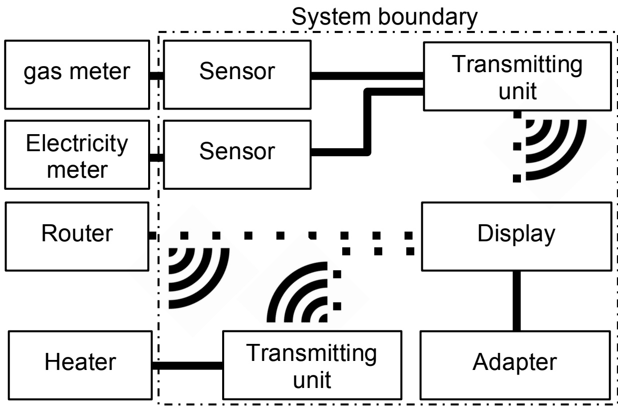


Figure 2: Schematic visualization of the setup of the multifunctional HEMS.

The system consists of an 8" touch screen, two sensors for, respectively, the gas and electricity meter, two transmitting units for, respectively, the meters and the heater (i.e. furnace for the central heating system), an adapter and, depending on the house, 0-3 repeaters (to increase the signal strength of the wireless communication between transmitting unit(s) and the display). Communication between the different parts happens by means of z-wave but a wireless router also needs to be present in the home for two-way communications outside the home. It is estimated by the manufacturer that the multifunctional HEMS uses 56 kWh per year, equivalent to using the display 14 minutes per day. An accompanying website is also present where more information on the energy bill and energy savings advice can be found.

In a later, improved version of this multifunctional HEMS, the energy consumption was optimized by changing the transformers present in most units to switching adapters, reducing the size of the 8" display to a 7" display, wiring the display to the heater and omitting the need for an additional Wi-Fi router (asides from the one assumed to be present within the home). The new configuration uses an average of 44kWh per year under normal use of the display. Switching adapters are currently becoming the norm in almost all appliances and therefore the new configuration is more comparable to the HEMS currently coming to the market. Based on what was known of the new configuration, the eco-costs and CED of the new multifunctional HEMS were calculated and presented next to the results of the old configuration.

The third HEMS, the energy manager, gives real-time and historical feedback on the electricity consumption of individual appliances. The provided software can be used to manage if and when the connected appliances consume electricity. (Figure 3).

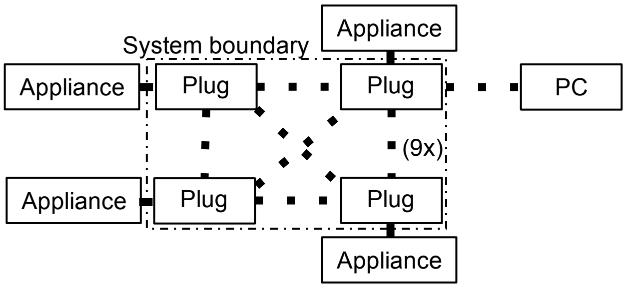


Figure 3: Schematic visualization of the setup of the energy manager.

The system consists of individual plugs in a Zigbee mesh network. The plugs of the appliances are inserted into the plugs of the energy manager, which are inserted into the wall sockets. One plug is wired to transmit the data from all plugs to a USB stick inserted in a participants' personal computer. For this study a set of nine plugs is sampled (only four are visualized in Figure 3) which use 3,6W when all connected appliances are switched off *via the software* and 9,9W when all are 'on' *according to the software*. It is estimated by the manufacturer that the nominal consumption is 43 kWh per year, equivalent to all connected appliances being switched off 19 hours a day. If the energy manager is only used to monitor consumption, it would use 87 kWh per year.

3.2 Description of the savings scenarios

This section presents a calculation for the net energy savings. For the energy consumption of households, the rounded off Dutch averages of 3500 kWh and 1600 m3 of gas [12] were used which equals 12600 MJe plus 52,800 MJth of energy per year. An increase in electricity consumption of 1,5% per year was included. To estimate the electricity and gas prices, a number of Dutch energy comparison websites for consumers were consulted and an average distilled at 0,22 €/kWh and 0.65€/m^3. Rises in the price of energy were not taken into consideration.

Based on literature, scenarios were developed for the potential savings. As the savings in literature vary for different studies [8, 13], it was decided to create six savings scenarios (Figure 4). The duration of use (i.e. the use–phase) was set to five years as it was assumed that this was within the technical life span of these HEMS. In these scenarios hypothetically 2, 4, 6, 8, or 10% savings were achieved by introducing a HEMS in comparison to the pre-intervention baseline consumption. Consecutively these savings on baseline consumption were maintained in the following five years. So no fallback or additional savings in the consecutive years was assumed. For reference, 7% savings in gas is equivalent to reducing the thermostat settings 1 °C [14]. 10% savings in electricity is equivalent to replacing four to five 60W incandescent light bulbs with CFL bulbs or reducing 62,5% or all of the standby consumption of appliances [15, pg. 395-397]. So technically the mentioned savings scenarios are attainable for households.

In actuality however, it is more likely that households will fall back to their old consumption patterns (to a certain extent) [1, 6]. Therefore a 'fallback' scenario was also developed in which for the first half year (gas and electricity) savings of 8% were achieved, the consecutive year savings reduced to 4%, after which households fell back to their old consumption levels for half a year. For the remaining 3 years, the gas consumption remained constant at 0%, while the *electricity* use resumed to follow the national trend by increasing 1,5% per year [12].

As all three HEMS gave feedback on electricity consumption, but only the multifunctional HEMS gave feedback on gas consumption, the hypothetical savings were only calculated for the type of energy households received feedback on. This was done because there is currently little evidence to calculate a potential spillover effect to other forms of energy consumption.

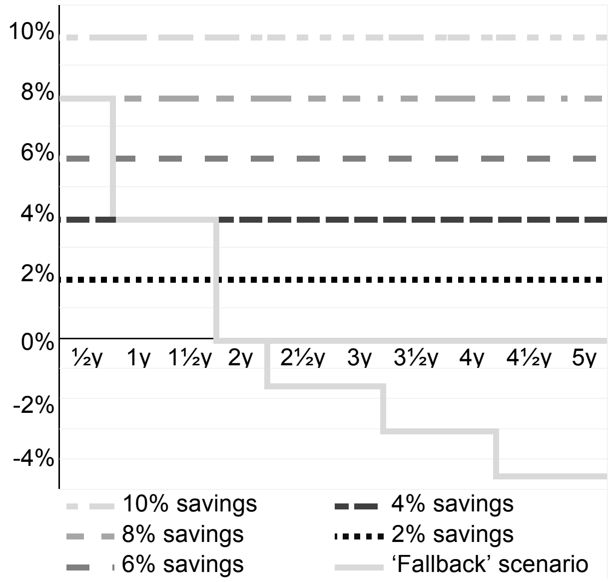


Figure 4: 6 Savings scenarios over a 5-year period in comparison to pre-intervention baseline consumption.

For the energy manager, the situation is complex as the potential savings are achieved with a set of individual plugs. Energy consumption feedback for a single appliance is a fraction of the total energy consumption of a home. Savings with a HEMS intended for one appliance would, on the basis hereof, only make a small dent in the total energy consumption of a home. However, disaggregated feedback is believed to be more effective than aggregated [16], but more hardware is needed to deliver the feedback from a number of individual appliances. Extrapolating the savings to a percentage of the total electricity consumption is difficult because this is dependent on many variables. The energy consumption of individual appliances can vary widely and the possibilities to save are dependent on the type of appliance. Additionally, the behavior related consumption for individual appliances can vary strongly. The calculation would therefore become too hypothetical. As such, the savings scenarios were left the same as with the other two HEMS and were calculated on the basis of the overall electricity consumption. However, consideration should be given to these issues when viewing the results.

3.3 Ecoinvent

Using the Ecoinvent database [17] the eco-costs, cumulative energy demand (CED) and economic payback time for each HEMS were calculated. These two single indicators were chosen because the CED gives an accurate depiction of the energy invested versus the energy saved, the main objective of this paper. However the drawback of this indicator is that it focuses too singularly on energy and aspects such as toxicity and disposal are not accurately depicted. Therefore the eco-costs indicator was also chosen to assess the environmental burden.

All three HEMS were disassembled and weighed or measured. The printed wiring boards (PWB) were weighed after removal of connectors and copper transformers. The type of PWB was compared to the PWB's in Ecoinvent and the most similar PWB selected, in this case the PWB for a laptop mainboard. For the display, the standard 17” display in Ecoinvent was used and the value scaled to compensate for the smaller area of the 8” display. A number of assumptions were made. It was assumed that all parts were produced in China while assembly took place in Europe. It was assumed that all PWB's were lead free. The lifespan of the battery used in the energy monitor was set to one year.

4 RESULTS

This following section presents the results from the eco-cost and CED calculations. First the eco-costs and CED of the HEMS are presented (Table 1) after which the CED will be used in the scenarios to calculate at which point in time the energy saved exceeds the energy invested.

	Energy monitor	Multif. HEMS	Multif. HEMS new	Energy manager
CED prod+disp	231MJ	1535 MJ	1176 MJ	1285 MJ
CED use phase	534 MJ	3389 MJ	2676 MJ	2639 MJ
Total CED	765 MJ	4924 MJ	3852 MJ	3924 MJ
Eco-costs prod+disp	€4.44	€33.91	€26.09	€24.75
Eco-costs use phase	€4.62	€29.38	€23.19	€22.87
Total Eco-costs	€9.07	€63.28	€49.28	€47.62

Table 1: CED and Eco-cost calculations for production, use and disposal, calculated over 5 years.

Table 1 shows that when calculating the CED over a five-year period, the use phase is more energy intensive than the production phase. The disposal phase is by far the least important. However, the eco-cost indicator gives more weight to the production and disposal phase. The results show that the overall impact is dependent on the type of HEMS. It also shows that the improvements to the multifunctional HEMS make significant impact for the use phase as well as the production and disposal phases. The CED and eco-costs are reduced by more than 22%.

Using the six scenarios from Figure 4, Table 2 shows the breakeven point for each scenario and HEMS respectively. The energy needed for production and disposal was used as negative starting point. Then for each consecutive half year, the CED of the home was calculated based on the total electricity (and gas) consumed (including the electricity needed to run the HEMS) with, dependent on the scenario, a subtraction for the energy saved through the use of the HEMS. This was then compared to the CED for ‘business as usual’ i.e. no HEMS was installed, no energy was saved and the electricity consumption followed the national trend. When the CED in the scenarios was less than ‘business as usual’, the net energy savings were considered positive and a ‘+’ was noted. When the CED was more than ‘business as usual’, due to the energy needed for production, use, or disposal of the HEMS, a ‘-‘ was noted. The ‘multifunctional HEMS new’ is not displayed because the results were identical, with exception for the 2% scenario where the breakeven point was a ½ year earlier.

	'fallback'	2%	4%	6%	8%	10%	'fallback'	2%	4%	6%	8%	10%	'fallback'	2%	4%	6%	8%	10%
0y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
½y	+	+	+	+	+	+	+	-	+	+	+	+	+	-	-	-	+	+
1y	+	+	+	+	+	+	+	-	+	+	+	+	+	-	-	+	+	+
1½y	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+
2y	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
2½y	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3y	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3½y	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
4y	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
4½y	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
5y	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Energy monitor						Multifunctional HEMS (old)						Energy manager					

Table 2: Breakeven point for CED of 3 HEMS calculated for 6 scenarios.

The results show that all HEMS break even within two years for all scenarios. The simplest HEMS, in this case the energy monitor, quickly reaches a break-even point even with small savings. These are positive outcomes.

Table 2, however, also shows that as soon as the HEMS is more technically complex and the duration of use is short or the achieved savings are small, the benefits do not always outweigh the environmental costs. The more elaborate HEMS (i.e. large displays, multiple plugs or adapters, take longer to attain a break-even point.

To visualize the potential amount of net energy savings that can be achieved, Figure 5 gives a graphic visualization of Table 2 with the inclusion of the old and new version of the multifunctional HEMS.

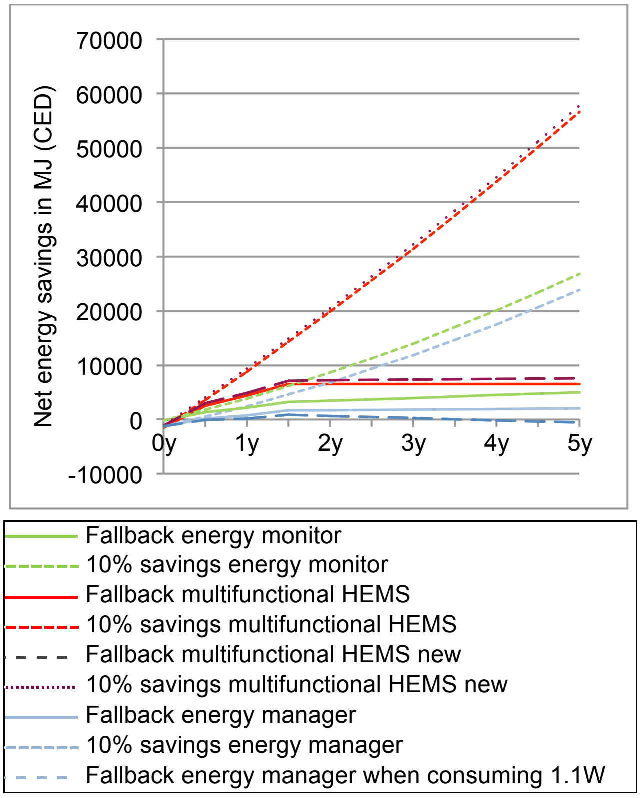


Figure 5: Net Energy savings in MJ for 3 (+1) HEMS for the ‘fallback’ and 10% scenario over 5 years.

Only two of the six scenarios are displayed for each of the three HEMS to visualize the difference: The best-case scenario with 10% savings and the fallback scenario. On paper, the Multifunctional HEMS (old and new) has the potential to achieve the greatest net energy savings in the 10% scenario due to the fact that it targets both gas and electricity. The energy monitor and energy manger only target electricity and as such their potential is less than half. In comparison, the potential net energy savings in the fallback scenario are marginal.

The flattening in the curves of the fallback scenario is caused by the electricity consumption of the HEMS's themselves. While the similarity between the curves of the old and new version of the multifunctional HEMS seem to suggest that the energy consumption of the HEMS itself is not important, the following example shows the contrary. Figure 5 displays an additional fallback line for the energy manager in which the plugs consume 1.1W continuously, i.e. 87kWh per year, rather than 43kWh. This is a real possibility in the case that households only use the HEMS to monitor the energy consumption of appliances but do not switch them off via the energy manager. Here, the line dips back under 0 after 3½ years, meaning that the energy manager does not break even any more.

The previous results have focused on the environmental costs, and this next paragraph will shortly discuss the economic costs in Table 3.

	'Fallback'	2%	4%	6%	8%	10%
Energy monitor	-€5	€81	€158	€235	€312	€389
Multif. HEMS	-€199	-€93	€88	€269	€450	€631
Multif. HEMS new	-€186	-€80	€101	€282	€463	€644
Energy manager	-€239	-€153	-€76	€1	€78	€155

Table 3: Economic profit in euros after 5 years for the 3 (+1) HEMS for the 6 scenarios.

While Table 2 showed that there were environmental benefits for all HEMS within two years at the most, the economic benefits are not positive even after five years for a number of scenarios. Notably, no HEMS are profiTable in the fallback scenario, and only the energy monitor is profiTable in the 2% scenario. With the energy manager it is the most difficult to achieve a positive return on investment, due to the high price tag and the fact that it only targets electricity consumption. While a negative return on investment may defeat the purpose for which households buy a HEMS, from and environmental perspective this is not necessarily a negative outcome: It can prevent a rebound effect where households invest the saved money in other energy intense products or services.

5 DISCUSSION

A life cycle analysis always contains a number of assumptions and as such there is always a relatively large margin of error. The comparison of the three HEMS was hindered because they are in effect three distinctly different products with, from an LCA point of view, distinctly different components. In particular the differences in printed wiring boards and displays made it more difficult to compare, and possibly increased the margin of error.

There is a reasonable risk that the HEMS will become obsolete before their technical lifespan has ended. The scenarios have the basic assumption that the HEMS are used by its owner for five years, or at least consume energy during that period. It is however possible that at a given point in time, the owner consciously or unconsciously discontinues the use of the HEMS, and that he or she consecutively cuts the power to the HEMS or lets the battery die. If households consecutively still manage to sustain their savings without receiving any more feedback, the lines in Figure 5 would be steeper. However, there are strong indications [1, 6] that a certain amount of fallback will occur, resulting in a flattening or even negative bend of the lines.

It is not known if a spillover effect can be achieved where savings in a different type of (indirect) energy other than the one that is targeted can be achieved. There is little evidence available on spillover effects, but it is possible that this will occur. In such a scenario, a HEMS can be more profiTable.

The calculations in this article are only based on the physical HEMS itself within the system boundaries as shown in Figures 1,2 and 3 on pages 2-3. However, there are two issues concerning these system boundaries that should be taken into consideration when viewing the results. First of all, the peripheral devices outside the system boundaries are essential for the functioning of the HEMS mentioned in this article and need to be present. The HEMS will not work without respectively a (smart) meter, router, or PC. These peripheral devices also have embedded energy and use electricity to function. While it can be argued that in some cases the energy would be consumed anyways, this will not hold true in all cases.

Secondly, nowadays it is commonly advocated or, in certain countries, legislated to implement a smart meter alongside a HEMS [18]. The calculations in this paper exclude the LCA of a smart meter. For the discussion on net energy savings *within* the home and simply on the basis of the technical complexity of a smart meter in comparison to a HEMS, a strong note of warning should be given as to whether implementing smart meters is environmentally beneficial. However, there is another side to this coin. There is a wider discussion taking place concerning the implementation of smart metering, and savings within the home is but one of reasons for which smart meters are being advocated. Smart meters are often regarded as part of smart grid developments. Smart grids focus on peaking shifting, e.g., through dynamic pricing schemes. This process employs smart meters together with HEMS that provide real-time pricing, which intends to give consumers the incentive to reduce electricity use during high-priced peak periods. The calculations within this paper were based on net energy savings within the home that can be achieved by means of a HEMS. In contrast, the environmental benefit of a smart grid is in the creation of more evenly distributed grid-loads. Research from 1987 implementing HEMS with pricing schemes has shown that the overall consumption is not reduced but rather shifts to periods with cheaper electricity [19], implying that smart grid systems mainly lead to different energy usage behavior (and not necessarily to energy conservation). This makes the calculations of the environmental benefits far more complex and outside the scope of this paper.

6 CONCLUSION

Referring back to the objectives as stated in chapter 2, all three HEMS can theoretically achieve net energy savings and a positive return on investment within their technical lifespans. However, particularly for the energy manager, substantial energy reductions need to be achieved before the HEMS becomes economically (and environmentally) viable. The chances that net savings will actually be achieved are dependent on a number of factors into which there is currently too little insight. It is unclear how many of these HEMS will still be in use after five years. It is also unknown how the savings of households will progress in the course of five years, as this has not been documented in research up to now. Additionally savings over such a period are difficult to calculate and to trace back to a particular intervention.

The reservations that were voiced in chapter 2, concerning whether there would be a positive impact for more complex HEMS, were not confirmed. The more complex HEMS also have positive environmental results after 5 years. However, the results from the multifunctional HEMS and energy manager do still show that care should be taken that HEMS are not developed with unnecessarily elaborate parts or functionalities and that their own electricity consumption is minimalized.

There are a number of conclusions that can be drawn for the individual HEMS based on the schematic visualization of the 3 HEMS in Figures and Tables 1,2 and 3 and the results in Figures 4 and 5.

The energy monitor is technically the simplest HEMS and dependent on the least amount of peripheral devices. Figure 5 shows the potential net energy savings that can be achieved are relatively high. However, the potential to use persuasive technology [20] or other behavior change strategies [21] are limited due to the type the display. Therefore, while the small display is positive for the CED, it could limit the actual potential to achieve net energy savings through behavior change.

The results in Table 1 for the new version of the multifunctional HEMS show that reducing the amount and size of parts and the HEMS' energy consumption has effects on the net energy savings. However more is needed to prevent the line from flattening in the fallback scenario. This HEMS has the most potential on paper for net energy savings due to the inclusion of gas consumption. Heating is the main source of CO_2 emissions in homes in the northern hemisphere, yet few HEMS bring this across. It is however unknown if the multifunctional HEMS also has the most potential to effectuate behavior change and thereby create actual savings. This is likely dependent on the visualization of the feedback on the display.

A number of different paths could be taken to increase positive net energy savings of the Energy manager. It is a modular system and can be extended at will. Therefore one option could be to only implement plugs on 'high potential' appliances; those with high energy consumption and large feasible savings such as the pump for underfloor heating and close-in boilers. Another option would be to use a different marketing model, e.g. by leasing or renting them to households for a short period after which this can be repeated with a next household. This option can harness the effectiveness of disaggregated feedback [16] without the drawback of the extended energy consumption during the use phase. A third option would be to combine a very modest number of plugs from the energy manager with an energy monitor. This can be used for the incidental testing of the consumption of different devices and consecutively for the permanent management of the 'high potential' appliances while keeping tabs on the overall consumption.

Finally, In light of the uncertain long-term effects of HEMS it can be argued that these devices should not be developed as stand-alone, dedicated products, but should be integrated in existing products instead. Care should however be taken that the simplicity and accessibility [22] of the feedback is maintained. This is an important, yet controversial issue. Integrating a HEMS in an app, TV page, or thermostat can arguably contribute to the HEMS functionalities being snowed under or forgotten amongst the rest of the functionalities or apps. In conclusion, it is important to weigh the different issues and find a balance that does justice to the odds that are at stake.

7 ACKNOWLEDGMENTS

We extend our sincere thanks to Joost Vögtlander and the companies involved for their input on the calculations.

8 REFERENCES

[1] van Dam, S.S., C.A. Bakker, and J.D.M. van Hal, 2010, Home Energy Monitors: Impact over the Medium-Term, Building Research & Information, 38/5:458 - 469.

[2] van Dam, S.S., C.A. Bakker, and J.D.M. van Hal, 2012, Insights into the Design, Use and Implementation of Home Energy Management Systems, Journal of Design Research, 10/1:86-101.

[3] Klopfert, F.d.r. and G.g. Wallenborn, 2011, Empowering Consumers through Smart Metering, Report for BEUC, the European Consumer Organisation, Brussels.

[4] Ueno, T., et al., 2006, Effectiveness of an Energy-Consumption Information System for Residential Buildings, Applied Energy, 83/8:868-883.

[5] Wood, G. and M. Newborough, 2003, Dynamic Energy-Consumption Indicators for Domestic Appliances: Environment, Behaviour and Design, Energy and Buildings, 35/8:821-841.

[6] van Houwelingen, J.H. and W.F. van Raaij, 1989, The Effect of Goal-Setting and Daily Electronic Feedback on in-Home Energy Use Journal of Consumer Research 16/1:98-105.

[7] Hutton, R.B., et al., 1986, Effects of Cost-Related Feedback on Consumer Knowledge and Consumption Behaviour: A Field Experimental Approach, Journal of Consumer Research, 13/3:327-336.

[8] Darby, S., 2006, The Effectiveness of Feedback on Energy Consumption. A Review for Defra of the Literature on Metering, Billing and Direct Displays, Environmental Change Institute, University of Oxford.

[9] McCalley, L.T. and C.J.H. Midden, 2002, Energy Conservation through Product-Integrated Feedback: The Roles of Goal-Setting and Social Orientation, Journal of Economic Psychology, 23/5:589-603.

[10] Willis, R.M., et al., 2010, Alarming Visual Display Monitors Affecting Shower End Use Water and Energy Conservation in Australian Residential Households, Resources, Conservation and Recycling, 54/12:1117-1127.

[11] Abrahamse, W., et al., 2007, The Effect of Tailored Information, Goal Setting, and Tailored Feedback on Household Energy Use, Energy-Related Behaviors, and Behavioral Antecedents, Journal of Environmental Psychology, 27/4:265-276.

[12] EnergieNed, 2008, Energie Informatiebank, Gemiddeld Elektriciteitsverbruik Huishoudens [Energy Information Database, Average Electricity Consumption Households], [Online], Available at: http://www.energiened.nl.

[13] Abrahamse, W., et al., 2005, A Review of Intervention Studies Aimed at Household Energy Conservation, Journal of Environmental Psychology 25/3:273-291.

[14] Milieu Centraal, 2012, Bespaartips Verwarming [Savings Tips for Heating], [Online], Available at: http://www.milieucentraal.nl.

[15] Zimmermann, J.-P., et al., 2012, Household Electricity Survey: A Study of Domestic Electrical Product Usage, Intertek Testing & Certification Ltd
[16] Fischer, C., 2008, Feedback on Household Electricity Consumption: A Tool for Saving Energy?, Energy Efficiency, 1/1:79-104.
[17] Ecoinvent, 2012, Database Ecoinvent Data V2.2, [Online], Swiss Centre for Life Cycle Inventories, Available at: http://www.ecoinvent.org/database/.
[18] Darby, S., 2010, Smart Metering: What Potential for Householder Engagement?, Building Research & Information, 38/5:442 - 457.
[19] Sexton, R.J., N.B. Johnson, and A. Konakayama, 1987, Consumer Response to Continuous-Display Electricity-Use Monitors in a Time- of-Use Pricing Experiment, The Journal of Consumer Research, 14/1:55-62.
[20] Fogg, B.J.,2003 Persuasive Technology: Using Computers to Change What We Think and Do. Morgan Kaufmann.
[21] Lockton, D., 2009, The Design with Intent Toolkit V.0.9 [Online], Available at: http://architectures.danlockton.co.uk.
[22] Fogg, B.J., 2009, A Behavior Model for Persuasive Design, In: Persuasive 2009, The 4th International Conference on Persuasive Technology, Claremont, California, USA.

ENERGY EFFICIENT LED LIGHTING of the historic city center of Sarajevo

Srdja Hrisafovic[1]

LIGHT is one of the most inspirational media for conceptual definition of architecture.

Fig 1. SARAJEVO

"Each particular place has its light which differs at any given moment from any other place", claimed Marietta Millet in her book Light Revealing Architecture.

But what happens at night? Is it possible to interpret the daylight specificum – so crucial in determining the genius loci - with artificial lighting? Could the city lighting be unique and authentic, while also technologically advanced and energy efficient? These were the questions we were seeking the answer while working on the concept for the master plan of the illumination for the historic core of Sarajevo – Bascarsija, which also included the bridges on the Miljacka River. Our major concern in this project was how to improve energy efficiency to have a green lighting, and at the same time to build the space with light, in human scale, pleasant, warm and intimate

What will be the definition of GREEN LIGHTING as a part of green design?

ENERGY EFFICIENT LIGHT a ratio of the amount of light and intensity versus energy consumption. To spend less energy for the grater amount of light.

NON POLUTING LIGHT where the light fittings using precise optic that directs light toward the surface or object of interest, and not wasted in to the dark sky.

CONTROLEABLE LIGHT the possibility of reducing or increasing light intensity versus needs (traffic flow or the flow of people). The possibility of communication between light fixture and lighting operation centre for example login failure, blown lamp etc.

Sarajevo spends 2.5 million EUR. a year for the city lighting. 2.300.000 EUR. we spend on electric energy the rest of 200.000 EUR. is maintenance, and disregarding part goes on new luminaries and lamps that could increase energy efficiency and durability of the lighting system and improve ecological sustainability of the installation.

The spatial plan of Canton Sarajevo does not contain lighting master plan. This document should be an overall lighting strategy that articulates the city as a functional and aesthetical coherent whole, including a segment of environmental protection, energy efficiency and general approach toward sustainable urban planning when it comes to lighting design.

In the absence of such a document Sarajevo still have yellow sodium light on major streets, lighting fixtures are mostly more than 15 years old, with optic that spill the light in atmosphere. Losses are huge. With careful planning we could save at least 1/3 of current spending for energy.

Master plan for illumination of Bascarsija addresses all of these issues and on top of that we build the space with light, in human scale, pleasant, warm and intimate.

CONCEPT

What inspired our concept was professor's Naithart description of urban setting of Sarajevo, from the book *Architecture of Bosnia and the Way of Modernity,* written in 1953, *quoting*:

"The road is the spine of the town, and the valley its shape, the Charshija (business centre) its hart, the vegetation its lungs, and the river its soul. Men are the measure of everything".

Judged by today's standards, this is a romantic and long-forgotten urban proposition. The concept was to retrofit that idea using light to build the space of Bascarsija.

Fig 2. Visualization of the master plan for Bascarsija

The client, the city government, had strict criteria for the illumination of Bascarsija as a space with very specific ambient demands. No candelabras; light sources are not allowed to be seen; energy efficient, long-lasting, small, non-prominent lighting fixtures. To these demands we answered with a concept that is treating the small-scale urban space as if they were interior spaces, illuminated with daylight white, low positioned, interior lighting. Lighting fixture almost invisible, with a low light level, so the space retains it intimacy. For this type of illumination the perfect solution was LED.

MASTER PLAN - BASCARSIJA

Working on the MASTER PLAN or design with light, the first step was to determine the prime and secondary axes of light and focal points.

Fig 3. Master plan divided in to 3 parts

The main street, as the main point of interest, becomes the prime axis of light divided into three parts: entrance, piazza with points of interest, and visual terminus. The secondary axes are the streets with less pedestrians walking through, in these streets the light level is lower and light is warmer.

LIGHT WALK or building space with light

Fig. 4. Aeroplan restaurant photo (photo M. Bernfest)

The first part of the light walk begins with artisan shops with low eves on the both sides of the street. As the main source of light, we designed costume LED fitting as the streetlight hidden under the eaves.

Entrance to the street space has been accentuated with illuminated facades of the old restaurant. Lowering the colour temperature and the luminance level on the white facades of upper floor, the overall light effect of the street was balanced.

Fig. 5 water feature-mosque wall (photo M. Bernfest)

The second parts of the light walk beginning with theatrical light of the wall with a water feature of the 15th century mosque. The little piazza has been illuminated with high positioned reflectors. This kind of light is used to accentuate yellowish limestone on the wall and the street. Wall openings, where one could peek in to the mosque garden, are accented with a hidden LED. Illuminated old chestnut tree is reflecting the play of light and shadow upon walkway.

Fig. 6. Morica Han (photo M. Bernfest)

The last part of the light walk is calming. Regular rhythm of streetlight is disrupted by accentuation of the white facades. Illuminated in a same manner like a first part of the street, regular rhythm of light is preparing one for the visual terminus. Light walk will culminate with higher luminance level reflecting from the beautiful mosque at the end of the street.

The Old Bascarsija is now bathing in comfortable white light. This light is not just an ordinal street light which provides just a visual security. It is the light that modulates the space of the street. Technically speaking, this light is energy efficient, cheap to run, discreet and focused, so it is also friendly towards a dark sky. New luminaries and lamps increased efficiency and durability of the lighting system and improve ecological sustainability of the installation. At the same time the lighting level is greater than before.

Walking through the street at night, the concept of intimacy of interior space is becoming obvious. The space was built with light.

BRIDGES

Fig 7. Master plan bridges / Bascarsija

Second part of the master plan, was illumination of the bridges on the river. The concept was to illuminate the bridge space, not just the silhouette.

Seven bridges are illuminated, and each of them has a different story. The illuminations differ in regard to the position, history, and materials they were built of. To develop our concept, we worked on two levels of illumination. The first one is light illuminating horizontal plan, which is important for understanding of the urban typology from the neighbouring hill slopes. The second one is vertical illumination, which builds the space of the bridge.

Fig. 8. Latin bridge (photo M. Bernfest)

Fig. 9. Sehercehajin bridge (photo M. Bernfest)

Discreet illumination highlighted just the silhouette of beautifully curved form of this two arched stone pedestrian bridges, dating from the Ottoman architecture. Arches, on the other hand, are illuminated with RGB flour lamps to get a precise colour rendering for the limestone construction. Changing the light temperature creates an impression of the bridge flying above the river. At the entrances are the candelabras with mirrored technology for indirect lighting. The candelabras are forming the bridge inner space with light and their specific look put the accent on entrances.

Fig. 9. Eiffel bridge (photo M. Bernfest)

On the steel bridges from the Austro-Hungarian period, the construction assembly and the handrail have been illuminated. The concept is to illuminate bridge inner space while erasing its silhouette. Here we highlighted the notion that the night perception of the form has to be different then the daytime perception.

Fig. 10. Eiffel bridge (photo M. Bernfest)

Concept for illumination of Eiffel's bridge is to show the passing of time. The iron structure is illuminated with RGB LED changing colours every hour, starting from the cold spectra of green to red at midnight, through blue spectra till the morning hours. 15 minutes before full hour, primary RGB colours accentuated the structure announcing the new hour. Fence and pedestrian footpath are illuminated with white linear LED, hidden in the handrail.

CONCLUSION

Fig. 11 Trgovke (photo M. Aksamija)

The implementation of lighting master plan for Bascarsija started in February 2006 (and still going strong), when using LED fixtures as the streetlight was a pioneer design.

The lighting project turned into a big urban design project. It was conditioned with renovation of the footpaths, rooftops, and facades of little artisan shops as well as historic monuments. The new illumination of Bascarsija enriched Sarajevo with new aesthetic and visual dimension of the spaces designed with light.

In this project, every street, square, bridge, every single space was designed with light, but without excesses or unnecessary dispersions. The novel LED technologies have been used in this project to ensure that the required level of light is energy efficient and that the light is directional and focused, so there is no light pollution. Special credit goes to the brave City Council and the Major in that time for accepting this project - a technologically original experiment, since this was one of the first to use custom LED fixtures for street lighting.

But some of the questions will stay unanswered. For example - for how long the LED will last? Is the initial cost worth savings in the future? The biggest problem we have is maintenance of the installed fittings. First, the City Council did not plan the additional budget for maintenance. Second, the firm, which maintains the city illumination is not educated enough for the new LED technology. Light technology and lighting design are developing faster than infrastructure and maintenance, and that can be the biggest problem with LED.

But we are certain of one thing. The measurement of power consumption gave us a special pleasure – it showed a saving of almost half of the expected volume for the street lighting of this area. In the end, the main triumph is aesthetic - we managed to highlight points of interest and key monuments, and still we succeeded to preserve the intimacy of the historic city center.

References

Marietta Millet: *Light Revealing Architecture;* Henry Plummer: *Poetics Of Light;* Henry Plummer: *Light in Japanese Architecture;* Juraj Naithart: *Architecture of Bosnia and the Way of Modernity;* Louis Kahn: *Light is the Theme;* *Urlike Brabdi, Light For The Cities;* Srđa Hrisafović handbook*: Designing With Light*

A study on energy and water management in green infill solutions and ground floor additions

E. Giacomello[1], J. Gaspari[2]
[1]Iuav University of Venice, Venice, Italy
[2]University of Bologna, Department of Architecture, Bologna, Italy

Abstract
If the Net Zero Energy Building standard is a suitable and achievable target for new constructions, adequate solutions in order to improve the quality of the existing building stock are still under investigation. The paper focuses on the potential benefit of transformation processes based on green infill and densification strategies at the ground level as start-up options for renewal interventions.
The study will deepen the thermal, energetic, acoustic and functional effects deriving from the application of green surfaces and architectural additions and will also define the consequences on water management at urban scale.

Keywords:
Urban regeneration, Water management, Technical green, Architectural addition, Energy saving

1 A STRATEGIC APPROACH TO REGENERATION PROCESSES

1.1 Starting position

The running energy demand reduction is one of the key issues for the very next future of the building sector. A more suitable "energy conscious" approach characterizes the new buildings conception even though the new construction activity represents the less significant part of the urban fabric from a quantitative point of view. As a matter of fact, the most part of several European cites is mainly composed of residential buildings built between the '60 and '80 years, which are affected by very relevant functional and performance deficits.

Consequently, the improvement of the average quality of the built environment is strictly linked to the identification of effective strategies for upgrading the existing built areas [1].

The critical topics are connected to thermal dispersions and very poor technological solutions. For this reason most part of the current studies focuses on the features and the performances of the building façades as they are closely related to a reduction of energy consumption, while refurbishing actions of the basement and ground floors are often overlooked [2].

Nevertheless these parts of the buildings are in many cases the more dispersive and exposed to degradation processes. Most cases the ground floor area is affected by a lack of services and connections with relevant consequences in terms of urban and social quality, while parking areas are often much more extensive than green areas. Even if this aspect is undervalued – or considered only for what concerns the social and perceptive issues – it has relevant environmental implications especially regarding to the water management. This is a key topic in the development of the urban fabric and it has to be accurately considered during the design phases [3].

It's important to remark that the redevelopment of ground levels - even the private ground floors of buildings and the public ones - is one of the most effective interventions in order to implement virtuous processes of renovation. One of the immediate effects arising from renewing public spaces is the attraction of private capital often coming from small investors, which generate an improvement of housing conditions, social control and environmental quality.

Working on the public ground is traditionally associated with introducing street furniture and pavements renewal, while nowadays several important features are linked to the performances obtained through innovative technical green and flooring technologies. Moreover the public spaces can be functionally improved in order to provide new services and utilities to the community with the consequence of a significant increasing of the environmental comfort as well as the economic value of the site.

The paper, which synthesizes the first results of a joint research activity run at the Iuav University of Venice and the University of Bologna, is therefore focused on the study of the benefits offered by green infill and densification strategies involving the ground floor areas with specific relation to energy and water management implications.

1.2 Regeneration options: ground floor and basement additions

In order to evaluate a wider range of intervention options, several case studies - sited in the principal European cities - have been considered and analyzed. Most cases the ground floors (and also the basements) are destined to garage or storage area and characterized by a lack of hierarchy of paths and connections which produces a very negative impact on the chance of relation to the surroundings. Car parks are prevalent compared to green areas, which are included necessarily as a compensative measure forced by law. Furthermore, there is often no distinction between car areas and pedestrian ones so that no public spaces for relation and interaction are available. As many neighbouring buildings belong to the same typology, the open spaces surrounding them become often urban voids without a function than parking. No services, no common areas, no playground, no shops are included in these residential areas.

So a wider perspective has to be acquired for operating on the ground floor and urban fabric regeneration. The compared analysis of the case studies pointed out that a hierarchical distinction of paths is necessary in order to separate pedestrian connection and car park routes. Car park areas have to be mitigated by adequate green areas and this is the most critical issue to be faced as the surrounding spaces are limited. For this reason the regeneration options have been oriented to provide some additional spaces following a design strategy based on volumetric addition intended as ground floor extensions.

The design concepts can be synthesized as follows:

- To place car park areas in a defined site with specific and separate routes.
- To provide adequate green areas, playground and common spaces for relation.
- To introduce new spaces for services, shops, common activities.
- To offer adequate connections, a hierarchical layout of functions and separate paths for private and public use.

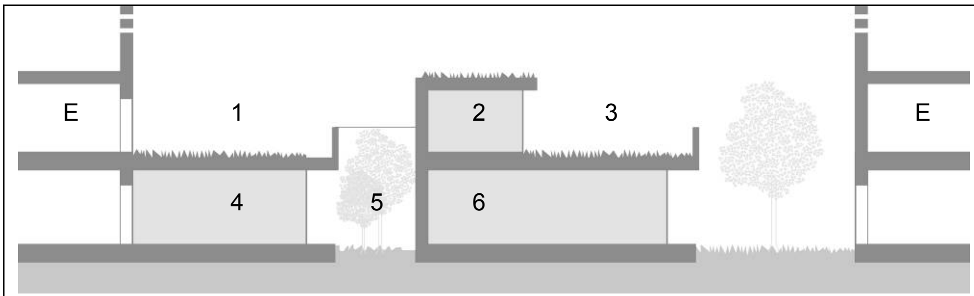
As several constraints often involve the street alignment, the distance between the buildings, etc., the volumetric addition can be placed on the back side in order to obtain a large platform connecting several buildings [4].

The platform is thought as a large green area which becomes a sort of "upper ground floor" (see table 1) where different public and collective functions can be hosted.

This large green roof is designed as an artificial soil with the idea to obtain technical performances comparable with a natural one [5]. This option allows to set a large car park under the platform, to move the existing garage from the buildings ground floor and to introduce in their place new services and shops in order to promote a multifunctional approach. Separate paths and connections are provided and new cloisters realized in the platform slab allow the natural light to enter in the car areas. New services, hall, shops can be placed on the ground floor, while some supporting activities can be hosted in the volumes emerging from the platform in green areas. This option can be implemented in the case an underground level is also provided. In such conditions, a greater number of services and shops can be placed on the ground floor area, car route are completely addressed to the basement, larger light cloisters have to be provided in order to guarantee high quality level to underground level. As a matter of fact this solution produces a densification process on the area, which is necessary linked to the introduction of new services and activities for economical reasons, but provides a significant increasing of the quality of the built environment.

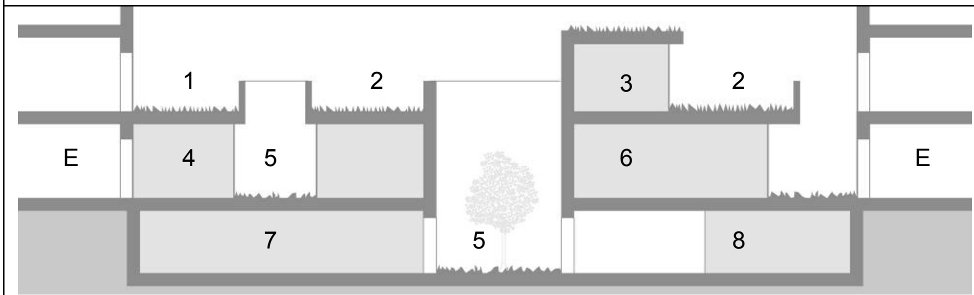
This strategic approach is also aimed at decreasing the energy demand for operation: on the one hand the introduction of the large platform allows to provide a buffer for the climate control and on the other hand the mass of the green roof provides an insulation effect both in the summer and in the winter time as well. The refurbishment of the ground floor of existing buildings allows to improve the insulation layer and to reduce dispersion towards the basement.

Nevertheless a much more remarkable feature is obtain through this regeneration option: the green roof of the large platform is thought to behave as a natural soil for what concern the mitigation of thermal conditions and the water management. The introduction of the green surface is a key factor to balance the economical implications and the environmental benefit of the regeneration process, but also a strategic tool from a technical point of view.



Ground floor addition

1- green terrace
2- supporting activity
3- green public space
4- shop and services
5- light cloister
6- park area
E- existing building



Ground floor and basement addition

1- green terrace
2- green public space
3- supporting activity
4- shop and services
5- light cloister
6- common activity
7- park area and services
8- garage
E- existing building

Table 1: Cross section of the addition models involving the ground floor and the basement.
Reference: Gaspari, 2012.

2 GREEN ELEMENTS AND ARCHITECTURAL ADDITION: TECHNICAL MATTERS

2.1 Technical green

The preliminary technical considerations that underlie to the decision-making process concerning the inclusion of the vegetation in urban spaces are mainly three:

1. Placing plants in a built environment is an agro-technical matter. Two different functional organizations must be integrated together: building components and living plants are characterized by different behaviours that - most of the times - are opposite. Furthermore, underestimating the vegetation's physiological processes can bring to irreversible project failures.
2. Vegetation has normally low installation costs, but requires frequent maintenance activities. The maintenance cost should therefore be an "expenditure item" placed ex-ante. At the present time the benefits derived by the vegetation presence are usually not calculated.
3. Vegetation significantly qualifies the anthropic environment from many points of view. The placement of green in built areas improves either the performances of the building envelopes, and the quality of the ground level, due to the actions of shading, shielding from the wind and damping the noise - thanks to the plants' foliage.

Moreover the plants are characterized by a physiology that, ensuring the survival of the organism, has the main effect of improving the air quality. In the surroundings of green areas some positive effects occur: variation of relative humidity, absorption of fine dust, conditioning of the air-motions, increasing of oxygen concentration, temperature control, etc. The physiological activities that implicate some positive technical effects on the built environment are summarized in Table 2 [6].

2.2 Technological choices and building implications

The introduction of some “living components” in the stratification of building system, adopted for realizing the volumetric addition, requires to pay attention not only to reach an accurate technical detail, but also to foresee possible interactions between components of different nature during the lifecycle. For example, the principal and very peculiar character of a green roof is to hold the rain water instead of disposing it as soon as possible like all other roofing solutions. This is an important benefit in terms of water management, but implicates several potential problems from a technical point of view.

First of all, an effective water stop and anti-root membrane are needed to protect the bearing structure and to avoid seepages. In order to optimize the behaviour of roof and to maximize the benefit for the addition, the stratification represented in figure 1 has been adopted as reference section.

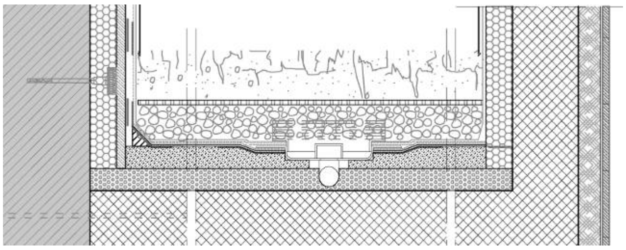


Figure 1: typical cross section adopted.

Reference: Gaspari, 2012.

Moreover an adequate drainage layer has been provided and insulation panels with waterproof membrane have been used to protect the new elevation structures in order to avoid the contact between wall's materials and the substrate or the vegetation, for preventing infiltration from the walls and the moisture onset.

PLANT FUNCTION	EFFECT ON THE BUILT ENVIRONMENT	GAINS
Phototropism Behaviour for which the plants' leaves assume a favourable configuration in order to intercept solar radiation ensuring the processes of photosynthesis.	*Shading* Orienting perpendicularly to the light stimulus, the leaves prevent the sun's rays reaching the surfaces under the green surface. The plants' foliage represent a mobile shielding layer, which self-adjusts according to the position of the sun.	1. Absorption reduction of solar radiation, by the built-up areas, then: - containment of surface temperatures - reduction of the external surface emissivity at high wavelength (and therefore reduction of radiant mean temperature)
Photosynthesis Reaction through which plants convert, in the presence of light energy, water and carbon dioxide in their nourishment (carbohydrates)	*Use of solar energy* A part of incident solar radiation is captured by plants to trigger the processes for the synthesis of carbohydrates	1. Reduction of mean radiant temperature 2. Absorption of carbon dioxide (carbon fixation) 3. Production of oxygen (photolysis)
Transpiration Phenomenon in which plants release water into the atmosphere in the form of water vapor	*Use of solar energy* The transition from liquid to vapor of water imply the use of solar energy	1. Reduction of mean radiant temperature 2. Ventilation and air movements around greened soil

Table 2: Plants' activities that affect the urban microclimate.

Reference: Giacomello, 2009.

3 THE HORIZONTAL GREEN SURFACES AS THERMAL AND WATER CONTROLLER

3.1 Meaning of the evapo-transpiration process: the reduction of heat island effect

Installing plants necessarily implies the presence of two other components: the soil and the water. Differently from built surfaces, the greened ones hold the water inside their stratigraphy. The ability to absorb water - *water storing capacity* - by a surface represents a key factor for the urban thermal control [5]: water is constantly moving from the ground to the atmosphere, thanks to the phase-change from liquid to gas. The *evapo-transpiration*, representing the water moving from the vegetal organisms and the soil to the atmosphere through the phase-change, is the opposite phenomenon to the rainfall, and is measured in mm/time. This process uses energy. As a result the greened surfaces dissipate the incident solar energy through the evapo-transpiration process.

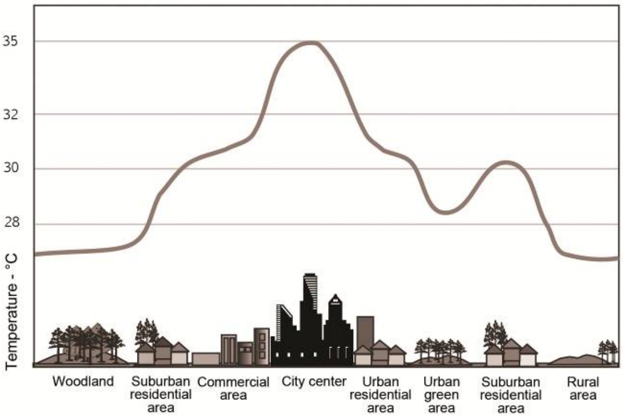


Figure 2: Urban heat island effect.

Reference: www.globalchange.gov> publications > reports > human-health.

As represented in figure 2, the building envelopes are affected by a heat accumulation during the day in the summer season producing the so called urban heat island effect which increases the temperature in the city center of several degrees more than the green rural areas. The phenomenon is perceptible during all the hours of the day and especially in the evening when the city center gets cool much later than the surrounding areas.

All greened surfaces (and moderately the drainage pavements that are able to absorb water and humidity) can be considered "cold surfaces" and, as a consequence, do not participate in the generation of the urban heat island.

The greened surfaces are characterized by a low emissivity, able to contrast the increasing of the air temperature in the city environment. Several experiments demonstrate that the air temperature in the immediate surroundings of a greened soil is approximately equal to the temperature of the open air, or, during the hottest days, higher of just 2-3 degrees [7], [8], [9]. Differently, the impervious surfaces of streets, pavements and traditional roofing (in metal, clay or membrane, etc.) can accumulate an amount of heat able to increase their superficial temperature of 30-40 degrees [10], [11], [12].

3.2 Water retention and detention

The water storing capacity of the greened soil produces also important implications in terms of storm water runoff regulation. In most of the cities significant changes in the hydrological cycle occur, because of an extensive presence of impervious built surfaces: roofs, paved roads, sealed sidewalks and squares, etc.

Being a permeable surface, the drainage soil does not discharge all the rainwater towards the urban drainage networks, storing a considerable part of it which is slowly transferred to the atmosphere as vapor. The benefits from water storing capacity of the greened soils relate to two different time scales:

1. Long timing - seasonal/annual scale

Greened soils and drainage pavements generate a runoff characterized by low water volumes, and this value is considered as a "constant". This characteristic is conventionally expressed by the runoff coefficient [ψ], which represents the ratio between the collected and the released water by a surface, so it is a value between 0 and 1. If the coefficient value is close to 1, the runoff is greater; on the contrary when it is close to 0 is lower (see Table 3) [13]. The effects of water storage capacity in long timing are defined by the *water retention capacity*.

TYPE OF SURFACE	RUNOFF COEFFICIENT ψ
Asphalt or plates with sealed joints	0,85 - 0,9
Porphyry with sealed joints	0,75 - 0,85
Porphyry with not-sealed joints	0,30 - 0,70
Synthetic sports fields	0,60
Pitched roof > 3°	0,90 - 1,00
Pitched roof < 3°	0,80
Roof with gravel	0,70
Semi-intensive green roof	0,30
Soil, courtyard	0,10 - 0,20
Garden, park, green area	0 - 0,10

Table 3: Runoff coefficient of various surfaces.

Reference: Abram, 2004.

2. Short timing - rain event scale

- Reduction of the peak flow (for the most intense runoff): during a rain event, while the impervious surfaces generate a peak volume which is nearly equal to the rain peak, feeding the urban drainage networks, a greened soil produces a lower peak because part of the rainwater is detained by the aggregate materials and another part is slowly discharged.
- Delay of peak time: the peak discharged to the urban drainage network is delayed, after the critical moment of the maximum runoff.
- Reduction of total volume runoff (see figure 3).

The water storage capacity in short timing is defined by the *water detention capacity*.

The advantages deriving from water storage capacity are strictly connected to the increasing of the water infiltration into the ground and the reduction of the superficial runoff. The benefits of a drainage urban ground are numerous, influencing a wide-range of scales and interrelated each other:

1. The rain water fits in urban hydrological cycle's segment of the evapo-transpiration, thereby improving the air temperature control and reducing the urban heat island effect.
2. The minimum vital underground flow can be guarantee.
3. The soil fertility is maintained.
4. The flow reduction in the short time relieves the urban drainage network, allowing a greater overall efficiency.
5. The infiltration of rainwater, even if partial, ensures a natural filtration of pollutants and reduces the superficial erosion.

It seems then evident that the more the urban water cycle can be modified in order to perform similarly to the natural water cycle, the more the environmental quality would be improved.

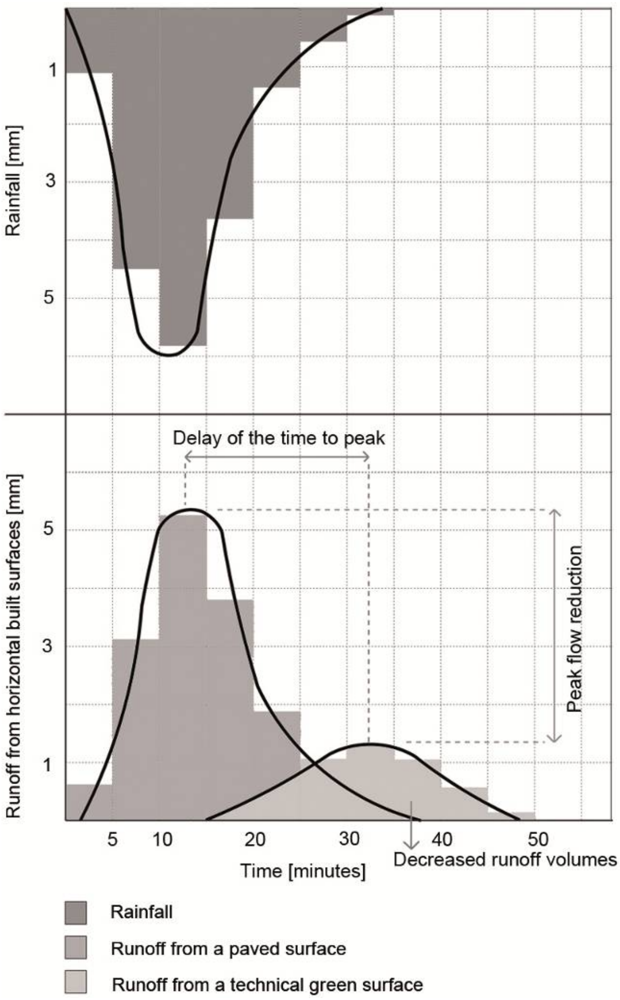


Figure 3: Water detention capacity: curve of intensity. Reference: Giacomello, 2012.

4 EXPERIMENTAL TEST AND SIMULATIONS

4.1 Test on water retention and detention

In order to clarify the role of the greened and drainage soils for the water management an experimental test was carried out.

The experiment was conducted by subjecting two different ground floor stratigraphies to a rain chamber controlled by a device able to modulate the intensity of rainfall events. The simulated rain (introduced into the rain chamber) and the runoff (flowing out from it) were measured in real time and, as a result, it was possible to determine the behavior of the different soils under examination. The aim of the experiment was to describe the hydrologic response of the soils during rainfall events characterized by different intensities. The values investigated were:

1. The water retention: described by the runoff coefficient ψ, calculated according to the FLL test.
2. The water detention: the reduction and the delay runoff peaks.

The two stratigraphies were characterized by different materials and thickness: the first one was composed by 10 cm of inorganic substrate, like mineral aggregates of volcanic origin; the second one was composed by 20 cm of inorganic substrate plus organic components, as coconut fiber. The hydrologic performances obtained by the two stratigraphies were significantly different: the soil with a lowered thickness had a runoff coefficient of 0,7, while the other, with higher thickness, had a runoff coefficient of 0,4. The water detention, that is a parameter dependent on a large number of variables, makes an appreciable difference between the two stratigraphies, but, in both cases, a delay of several minutes in the generation of the peak and also a significant reduction of its flow. The parameters obtained, which are correctly comparable to the ones in the scientific literature, were used to calculate the hydrological performances of a large urban land.

4.2 Simulation scenarios and comments of the results

In order to understand how drainage soils can influence urban hydrology, due to the water storing capacity, a simulation of conversion of existing impervious pavements into greened and drainage ones has been set using the city of Vicenza urban fabric as a case study. After having performed several analysis and measures concerning the land use, a map of density and ground floor condition has been obtained. Then several scenarios have been simulated considering the development of regeneration process through addition with green roofs, greened soil and drainage pavements.

Each scenario produces a new configuration in the density of the urban fabric and, of course, of the soil condition. As the chance of transformation of the urban fabric in Vicenza is very different from city centre and the suburban areas, the land use has been calculated and divided in four different percentiles and then an average condition has been considered.

During the simulation, the runoff reduction is calculated using two different runoff coefficients, resulting from the experiment described in the paragraph 4.1: ψ = 0.40 for the technical greened soils and ψ = 0.70 for drainage pavements (see figure 4). The results from the simulation illustrate that converting the 5% of the city's impervious surfaces into greened ones, the runoff reduction is 2,5% of the current urban runoff.

So, proportionately, a transformation of 10% reduces urban runoff of 5% and the transformation of 50% of the city's soil would reduce the annual runoff of 25%. Differently, converting the 5% of the city's impervious surfaces into drainage pavements the runoff reduction is 1,2% of the current urban runoff and, proportionally, the transformation of 50% of the city's soil would reduce the annual runoff of 12%

The simulation suggests that an organized distribution of greened surfaces inside a dense built environment contributes to the rebalancing of the urban hydrological cycle through water retention and water detention, gaining also all the benefits associated to water infiltration, i.e. the reduction of heat island effect and the mechanical and chemical filtration of rainwater.

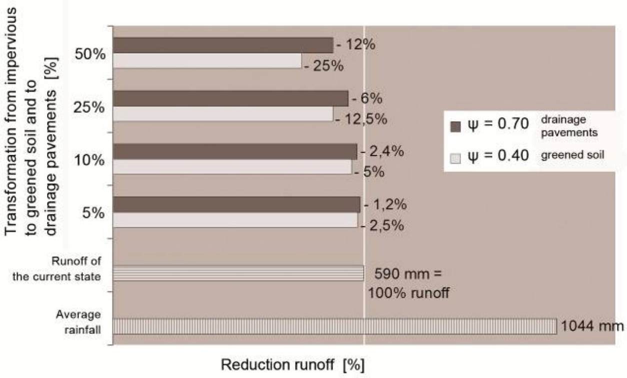


Figure 4: Runoff reduction of Vicenza city through the conversion of the impervious surfaces to technical greened soil and drainage pavements.

Reference: Giacomello 2012.

5 CONCLUSIONS

The paper offers a synthesis of a study concerning the chance of transformation, regeneration and densification of the built environment with the aim of offering possible solution to improve the quality of open spaces and connections between the buildings.

The analysis run on several European cities outlined a framework in which the condition of the residential districts requires not only to provide intensive refurbishment of the buildings, but also effective strategies of regeneration involving the surroundings. The proposed intervention strategy is based on some basement additions and ground floor renewal with the aim of providing new functional elements able to produce direct and indirect benefit for the users and the community. The additions can host services, shops and all the activities necessary not only for increasing the mixitè and the social interaction of the site but also to attract the financial resources to support the development of the initiative. The impact of densification is balanced by the introduction of large green platforms which includes all the addition. A new usable and suitable “upper ground level” is available: above the green surface there are promenade, play ground, supporting activities; under the platform there are park area, separate route, new shops and services.

Furthermore the green platform connecting the addition is a key tool from a technological point of view: it acts as a buffer zone exploiting the performances of the greened soils and drainage pavements.

The paper deepens the contribute of the green soils and drainage pavements in term of control and mitigation of solar radiation (especially in the summer season) and in terms of water management which is a very relevant issue in dense urban areas. A specific study has been run on the proposed technological solution in order to have a realistic framework of the potential expected performance level. Some simulation scenarios have been used to evaluate the effect of the proposed regeneration process based on the addition strategy in a dense urban fabric.

The obtained results and the adaptable character of the design approach suggest to deepen the aspects concerning the evaluation of the green and drainage surface impacts in terms of environmental quality and in the same time to investigate the feasibility of the addition strategy in terms of a balanced approach between social/environmental benefits and urban/economics implications.

6 REFERENCES

[1] Di Giulio, R. (edited by), 2012, Improving the quality of suburban building stock, Unife Press, Ferrara.

[2] Gaspari, J., 2010, “The addition strategy in building extension and sustainable transformation”, in AA. VV., *CESB 10 Central Europe toward Sustainable Building 2010 Proceedings*, Grada Publishing, Prague.

[3] Gaspari, J., Giacomello, E., 2010, “Green living technologies in sustainable refurbishment strategies”, in AA. VV., *CIB World Building Congress Proceedings*, CIB, Salford Quays UK.

[4] Gaspari, J., 2012, *Trasformare l’involucro: la strategia dell’addizione nel progetto di recupero*, Edicomedizioni, Monfalcone.

[5] Giacomello, E., 2012, *Copertura a verde e risorsa idrica. Implicazioni tecnologiche e benefici per l'ambiente urbano*, Franco Angeli, Milano.

[6] Giacomello, E., 2009, "Verde verticale: utilizzo del verde oltre le coperture. Tecnologie e applicazioni a confronto", *Modulo*, 349, 154-161.

[7] Hoyano, A., 1998, “Climatological uses of plants for solar control and effects on the thermal environment of a building”, *Energy and Buildings*, 11, 181-199.

[8] Wilmers, F., 1988, “Green for melioration of urban climate”, *Energy and Buildings*, 11, 289-299.

[9] Weiler, S., Scholz-Barth K., 2009, *Green roof system. A guide to planning, design and constructing landscapes over structure*, Hokoben, John Wiley & Sons.

[10] Baskaran, B., Karen, L., 2003, *Thermal performance of green roofs through field evaluation*, National Research Council Canada, www.nrc-cnrc.gc.ca/obj/irc/doc/pubs/nrcc46412/nrcc46412.pdf

[11] Yu, C., Hien Nyuk, W., 2006, “Thermal benefits of city parks”, *Energy and Buildings*, 38, 105-120.

[12] Feng, Chi, Meng, Q., Zhang, Y. 2010, “Theoretical and experimental analysis of the energy balance of extensive green roofs” *Energy and Buildings,* 7 pp.

[13] Abram, P., 2004, *Giardini pensili. Coperture a verde e gestione delle acque meteoriche*, Sistemi Editoriali, Napoli.

Going Green - How to Change the Rural in Order to Sustain the Urban*

I. Simić[1], A. Stupar[1], Z. Nikezić[1]
[1]University of Belgrade, Faculty of Architecture, Serbia

Abstract
This paper discusses rural settlements and their new role in the transformation of rural-urban relations. Urbanization has produced rapid population growth, uncontrolled expansion of urbanized territories and other changes that threaten the environment and its resources. So far, rural areas have played a passive role in these processes, surviving only as a resource for activities related to agricultural production. This paper examines the boundaries and relations between the rural and the urban, exploring the urban impact villages can successfully absorb in order to alleviate cities in their efforts towards sustainable development and integral 'green' environment.

Keywords:
Green Cities / Villages, Rural-Urban, pattern transformation and adaptation

1 INTRODUCTION

This research deals with relations between two essential components of the environment – the built and the natural, assuming that anthropogenic factors are the main cause of most existing environmental problems, and specifically ecological problems producing climate changes both on the local and global level.

Most of the scientific researches and official reports of international organizations involved in questions of environment show that these changes are directly caused by man's influence on the environment, producing the greenhouse effect mostly through the emission of GHG gasses. Cities and urban areas as dominant ecologically strained forms of human habitat and containers of these activities, are therefore seen as one of the major focal points when dealing with the GHG emission problems. The cities are seen as the major source of environmental problems (see global report of UN habitat for 2011), because they directly influence ecosystems, habitats, endangered species, the quality of water and air, habitat fragmentation. Thus, the global, regional and local influence of cities on the environment greatly influence climate change [1]. According to UNEP's report, urban activities generate nearly 80% of total CO_2 emissions, as well as significant amounts of other GHG. At this moment, over 50% of the world's population is lives in urban areas, compared to less than 15% in 1900.

In the context of influence that urban areas have on the environment, this research deals with the spatial and morphological characteristics of smaller urban and rural settlements in Vojvodina. The research is based on the premise that smaller settlements can have significant role in influencing a sustainable and 'green' development of cities they surround. The hypothesis is that a vital and sustainable network of smaller settlements can support the sustainability of cities by reducing burdens of its growth manifested through urban sprawl that harm the environment and induce climate change. The starting premise of this research is that sustainability of cities and urban settlements in Vojvodina is dependent on their urban and rural hinterland, as well as on established relations between city and village and all transitional types of settlements that the urban-rural continuum is composed of.

The aim of the research is to examine possibilities of solving ecological problems through the transformation of spatial and functional characteristics of smaller urban and rural settlements in Vojvodina, to define their possibilities of becoming 'green'. From the urban and architectural aspect, we will be looking at the possibilities for a village to adapt its spatial and morphological patterns to climate change, as well as to the needs of changing population whose life style now requires more 'urban' elements than currently exist. At the same time, the new 'green' city will still need the 'rural' village, to support its sustainable development.

Therefore the term 'rurban' settlements will be used in order to highlight the dual character of these settlements in Vojvodina, emerging as the basic conceptual characteristic that enables sustainable development. The term 'smaller' is used in order to point out the relation of size and in order to point out the relation of size and hierarchy (functional, spatial and demographic parameters) of these settlements compared to the network of larger and medium sized settlements spread across of Vojvodina and defined as such according to the Spatial plan of Republic of Serbia (SPRS), and the Regional spatial plan of Vojvodina (RSPV).

The settlements will be studied through three spatial levels: I- macro level, seen as the territory of the whole region with its network of settlements; II- level of the individual settlement as physical pattern; and III- level of the house and lot as the basic spatial and functional unit of the settlement.

2 THE GREEN CITY

Theories offer numerous, yet not always compatible answers to the questions raised in defining the sustainable city and achieving an ecologically responsible urban form. The terms 'ecological', 'green', 'compact' are used to specify different models that aim to achieve sustainability.

According to Beatley, a city can be characterized as 'green' if (1) strives to live within its ecological limits, (2) is designed to function in ways analogous to nature, (3) strives to achieve a circular rather than a linear metabolism, (4) strives toward local and regional self-sufficiency, (5) facilitates more sustainable lifestyles, and (6) emphasizes a high quality of neighborhood and community life [2].

2.1 Concepts of sustainable urban form

An integral theoretical framework for achieving sustainable and climatically responsible urban forms still doesn't exist. Theoretical concepts about compactness, dispersal, mixed use, etc. are trying to give a scientific answer to what physical frame of the city can be considered sustainable. Jabareen [3] in his evaluation of concepts develops a matrix in which he gives several possible models and urban form development directions, successfully avoiding generalizations, such as defining only one optimal model of uniformed parameters of density, mixed use, etc.

Even though there is no uniformed theoretical frame, contemporary theory and practice in most cases choose polycentric models and compact urban forms. The model of 'compact city', that is characterized by higher densities, mixed use and clearly defined urban borders, is considered to be an adequate framework that could direct the development of urban entities towards sustainability in the field of land use, and could prevent uncontrolled urban sprawl [4]. Compactness of built form and mix use is not important only for cities, but also for rural settlements, defined in the concept of 'compact villages'.

The fact is that neither compact building nor polycentric models of organization can be considered sustainable *per se*. Sustainability can only be achieved within the urban-rural system, that provide space with necessary dynamics, especially in the terms of settlement functions, transport, infrastructure and overall economy. The significance of the relation between city and village is also highlighted by Darko Radović, who indicates that these relations have to include 'compact urban structures with housing, services, and places of work that are concentrated in knots or junctions of a complex network of urban and rural settlements' [5].

2.2 Urban – rural relations and the character of 'rurban' settlements

Explanations of the terms urban and rural have always been based on highlighting their differences. They reflected the differences the city and the village used to manifest, differences that were evident in the physical, sociological, cultural and economical dimensions of the built environment.

However, nowadays we can identify major changes in the social and economic structure of rural areas. For example, in Vojvodina's rural areas, the social and economic structure is increasingly tied to urban functions. According to results of the UNDP study of village households, we find a significant proportion of mixed (48,8 %) and non-agricultural households (51%). As a result of a solid level of education, a large part of the village population in Vojvodina seeks employment outside agriculture. Therefore, the percentage of the village population that declares itself as agricultural is getting lower. It is important to point out that most of the village households in Vojvodina (66%), own relatively small areas of agricultural land (under 3 ha), while the share of non-agricultural households is increasing and reaches 62,5 %. These facts depict significant changes in the socio-economic structure of these villages and a rapid rise of urban activities [6].

According to Kojić, many city settlements in Vojvodina have the same characteristics as villages because 'their urban origins are similar, with differences brought in by the later development' [7].

Therefore, in this case, 'urban' is determined by the planned character of the settlement that was measured and registered within strict regulations, an orthogonal urban matrix of streets and lots, sewage and water infrastructure.

According to RSPV [8], settlements in Vojvodina are divided in three groups, based on the size of settlements, the professional structure of the inhabitants, the development of basic urban functions, as well as the position and significance of the settlements within the network. They are defined as:

- Cities – macro regional center and other regional centers
- Towns – sub regional and smaller centers
- Village settlements.

Based on the evident transformation and urbanization of Vojvodina`s rural settlements and on categorizations by criteria of size and function used in RSPV, we defined a specific group of 'rurban' settlements as the subject of our research. These settlements have a population ranging from 1000 to 10000 inhabitants, and developed functions in agriculture, industry and services, all interconnected in an elaborate urban-rural framework.

3 POTENTIAL(S) FOR SUSTAINABILITY

In order to conduct a comprehensive assessment of the potentials of sustainability of smaller rurban settlements in Vojvodina, it is necessary to establish a relationship between their spatial and morphological characteristics at different spatial levels, and define concepts and models for a sustainable urban form. Spatial planning and settlement development still treat space in a hierarchical manner. Size and scale are identified through administrative boundaries and typological classifications, dividing planning responsibility for solving, as Karrholm states 'inter-territorial problems of various fields of interest, which can lead to optimization of isolated elements, aspects or fields, but it will be difficult cope with multiple routes of the urban landscape' [9].

It is necessary to establish a relationship between different levels of physical structures, because, as Yaneva stated 'changing scales, jumping, surging, scaling up and down, lies in the very heart of the design process' [10].

If we intend to examine the impact of settlements on the environment, their spatial and morphological aspect needs to be understood as a multi scaled dynamic system that is constantly interacting with its direct and indirect environment (other systems). This requires a planning processes witch should be integrated with urban and architectural design.

3.1 Regional level - network of settlements

At the regional level, urban form is defined as 'the spatial configuration of fixed elements' [4]. At this level, key spatial characteristics are network density, dispersion, correlation, functional complementary settlement types and clear hierarchical distinction between the settlements that make up the elements (nodes) of networks.

The current network of villages in Vojvodina is evenly distributed as a result of strategic eighteenth century planning, which gave general direction of population distribution and anticipated the basic structure of today's settlement network. The main feature of these settlements is an inherited planned geometric composition.

This network has a rational structure within a well-differentiated hierarchical system. Six of the largest settlements with city status are evenly distributed throughout its territory: Sombor, Sremska Mitrovica, Subotica, Novi Sad, Pancevo and Zrenjanin. The highest ranking city is Novi Sad, classified as FWP of international importance by ESPON (European Observation Network), while other cities are functional urban areas of local importance. All urban areas are interrelated within their functional areas and mutually connected to other settlements due to a well developed network (Figure 1).

On this level we identified several elements which could support its sustainable development.

- **Network of small settlements -** the reorganization of Vojvodina, which was undertaken in the 18th century, defined the future sustainability of this area. In order to systematize and intensify agricultural production and colonize the region, the Austro-Hungarian Empire executed a radical reconstruction of all existing villages and towns, and planned a large number of new settlements. These actions contained elements of network spatial planning at the regional level, and contributed to a systematic coordination and intensification of Vojvodina`s development.
- **Network dispersion -** small settlements are evenly distributed in reference to each other and to larger urban centers. A strong urban and rural hinterland was formed, enabling the establishment of sustainable towns and cities.
- **Mobility –** the well-developed transportation network facilitates the mobility of population offering possibilities in sustainable transport. Major urban functions can be interconnected supporting a rational network of services. Infrastructure development includes better access to education, health and other resources, and can as well have a positive impact on the quality of everyday life.

  Development of these resources prevents trends of depopulation and migrations to larger urban areas creating a favorable environment for a future repopulation of the hinterland.

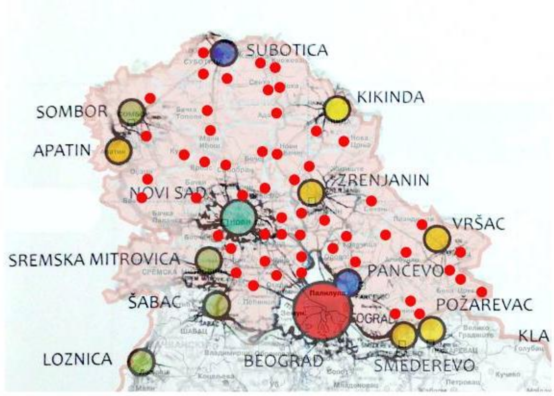


Figure 1: Network of cities and small settlements in Vojvodina

3.2 Level of settlements - morphological characteristics

At the settlement level, elements of urban form are defined by the configuration of streets and blocks, as well as houses. The patterns of Vojvodina's settlements are defined by natural-geographic and cultural-historical conditions.

As a part of the Austro-Hungarian Empire, Vojvodina became an area of multi-cultural and multi-ethnical co-existence. This formed a unique background for the development of specific architecture. With the introduction of cadastre, the conditions for planned reorganization of settlements were established. According to its characteristics, this urban matrix belonged to the "ideal city" concept which existed in the late seventeenth and the beginning of the eighteenth century in Western Europe [7]. Settlements are conceived as compact forms, an orthogonal matrix defined by two major axes, narrow and deep lots, wide streets and drainage canals (Figure 2). Dimensions of the blocks depend on the depth of the lots ranging between 200 and 300 meters in width and 200 and 500 meters in length [7].

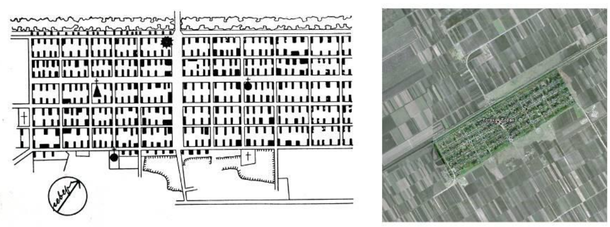


Figure 2: Torak - settlement planned according to the principles of 'ideal cities'

Analyzing the structure of settlements we can distinguish three basic elements.

- **Compactness** – settlements in Vojvodina, with their rectangular matrix, represent a concept convenient for a step-by-step reconstruction. Housing schemes and blocks have the ability to 'absorb' pressure of population growth providing adequate space for new compact structures, without expanding its territory to surrounding agricultural land.

- **Density** – compactness of the urban form of settlements is supported by its densification potential. Plots can become smaller in depth and width, without changing their primary purpose and house typology. Settlements in Vojvodina have low and medium densities, which make suitable for the application of eco-villages concepts.
- **Green infrastructure** – the potential of green infrastructure in Vojvodina's settlements is based on a standardized system of street profiles equipped with channels for collecting rain water (main streets are 34-38 meters wide, while local streets have a width of 11-16 meters). This provides opportunities for the development of public space, while large blocks facilitate a green infill.

3.3 Level of house/lot

The development of residential buildings in these settlements is influenced by existing standards. Standards that were applicable during the Austro-Hungarian rule have prevailed. According to the General instructions of January 1772, dimensions of a lot are set at a depth of 143.00 to 190.00 meters, and a width of 23 to 40 meters. Population growth caused further divisions of lots (Figure 3). Today, their average width is between 16 and 20 meters, while their depth has diminished in accordance to the size of newly formed blocks.

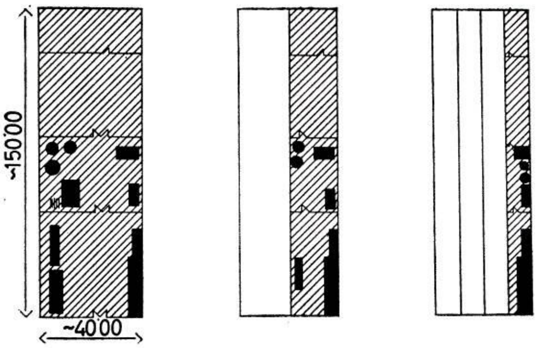


Figure 3: Densification by divisions of lots

Analyzing the structure of typical houses and lots we identified four basic tools for achieving sustainable development.

- **Passive solar architecture-** the average annual value of global irradiation energy on territory of Vojvodina is 1.300 kWh/m²/year. By comparison, the average value in Europe is 1,000 kWh/m²/year indicating a significant potential for the use of solar energy. The layout of a typical farmhouse is defined by the settlements urban pattern. Its regularity, position and morphological characteristics of the structure itself allow a rational utilization of solar energy (Figure 4).
- **Vernacular building principles -** principles of energy-efficiency are mainly based on the use of local available materials. Building with clay, straw and wood allows a development of technologies combining tradition with green architecture.
- **Wind energy -** As for wind energy, previous research showed that there are suitable sites for building wind generators in Serbia, on which the approximate 1,300 MW of wind generating capacity could be installed, reaching annual production of 2,300 GWh of electricity. Vojvodina is one of three favorable national sites for the use of wind energy. It covers approximately 2000 km2 and is especially suitable for the construction of wind generators due to already available road infrastructure, utility grids, small distance from large power consumers etc. Energy generators can be dispersed throughout the structure of the settlement (lots and blocks), or centralized (Figure 5).
- **Urban agriculture –** potentials for urban agriculture are based on changes in the social structure and a shift in human activities and behavior. Urban agriculture is expected to develop both in previously rural settlements that have undergone an urbanization process, as well as in restructured urban settlements.

Figure 4: Variants of solar housing design, Massachusetts Institute of Technology (MIT)

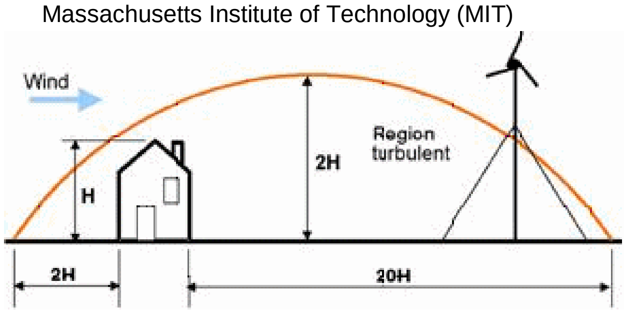


Figure 5: Guidelines for setting a small wind generator on a house lot

4 CONCLUSION

This paper aims to reveal the importance of urban-rural relations for the implementation of green and sustainability concepts. Special attention was given to smaller settlements in Vojvodina in an attempt to incorporate their potentials into an integrated and sustainable vision. We have suggested that the character and layout of these settlements can support their eco-friendly future simultaneously providing an acceptable base for regional networking. The transformation of small rural settlements into 'rurban' settlements can consequently influence the development of larger urban settlements giving them a better chance to avoid urban sprawl, maintain their present boundaries and develop into sustainable towns and cities.

In order to estimate the 'green' potential of settlements, three spatial levels where analyzed – the regional level (network of villages, towns and cities), the settlement level and the house/lot level. The identified elements and tools for achieving sustainability emphasize the relationship between existing morphological features and contemporary eco/green concepts of sustainable urban form.

Connecting tradition and innovation, old patterns and latest models it is possible to establish a new equilibrium between urban and rural settlements in Vojvodina. A new symbiosis between these spatial and functional entities could certainly become a useful framework for further understanding of integrated planning and sustainable development, but the outcome of 'green' visions and strategies has yet to be tested, evaluated and confirmed.

5 REFERENCES

[1] Alberti, M, 1999, The Effects of Urban Patterns on Ecosystem Function, International Regional Science Review 2005 28: 168.

[2] Beatley, T. 1995. planning and Sustainability: The elements of a new (improved?) paradigm. Journal of Planning Literature 9(4): 383-395.

[3] Jabareen, Y.R, 2006, Sustainable Urban Forms - Their Typologies, Models, and Concepts. Journal of Planning Education and Research, 26:38-52.

[4] Jenks, M. and Jones, C, editors (2010) Dimensions of Sustainable City. London: Springer.

[5] Radović, D. i Đukanović, Z. 2007, *Urbofilija/Urbophilia*. Beograd: Arhitektonski fakultet.

[6] Bogdanov, N., 2007, Mala ruralna domaćinstva u Srbiji i ruralna nepoljoprivredna ekonomija. Beograd: UNDP.

[7] Kojić, B., 1973, *Seoska arhitektura i rurizam*, Beograd: Građevinska knjiga.

[8] Regionalni prostorni plan AP Vojvodine (Regional spatial plan of Vojvodina), 2010, Zavod za urbanizam Vojvodine.

[9] Karrholm, M., 2008, Setting the Scale of Sustainable Urban Form – Some scale-related problems discussed in the context of a Swedish urban landscape. Conference Architectural Inquiries, Göteborg.

[10] Yaneva, A., 2005,"Scaling up and Down: Extraction Trials in Architectural Design" *Social Studies of Science* 35/6 (Dec) 867-894.

*Acknowledgement

This paper was realized as a part of the project 'Studying climate change and its influence on the environment: impacts, adaptation and mitigation' (43007) financed by the Ministry of Education and Science of the Republic of Serbia within the framework of integrated and interdisciplinary research for the period 2011-2014.

Assesment of Fuel Economy Improvement Potential for a Hydraulic Hybrid Transit Bus

Predrag Mrdja[1], Nenad Miljic[1], Slobodan J. Popovic[1], Marko Kitanovic[1], Vladimir Petrovic[1]

[1]Internal Combustion Engines Department, Faculty of Mechanical Engineering, University of Belgrade, Serbia

Abstract

Hybridization, in particular Hydraulic Hybrid Technology (HHT), is offering significant powertrain efficiency breakthroughs in near and mid-term. A data acquisition on a transit bus has been performed to assess the potentials for fuel consumption reduction based on deceleration energy calculations. Initial study suggests fuel economy improvements of 20 % are possible. Additional investigation was carried out to quantify fuel savings that would be achieved by implementing a start-stop system. Significant fuel consumption occurs during bus idling periods at bus stops and traffic lights. Analysis shows that more than 15 % fuel reduction is possible solely by turning off the engine.

Keywords:

IC Engine, Hydraulic Hybrid, regenerative braking, start-stop system, emissions

1 INTRODUCTION

Rising fuel prices and increasing awareness of environmental issues place greater importance on the quest for solutions that improve vehicle fuel economy and reduce harmful emissions. One of the many possible directions in that regard, but perhaps the most promising, is the hybridization of the powertrain. Hybrid drives combine at least two energy converters and two energy storage systems for powering the vehicle. Internal combustion engines, hydraulic or electric motors are most commonly used as energy converters in hybrid systems. Fuel tanks, electrochemical batteries and hydraulic accumulators are examples of energy storage devices. What all hybrid concepts have in common is the advantage of possessing additional energy sources which are characterized by different optimal operating conditions.

Achieving improved fuel economy, lower emissions and relatively low price without sacrificing performance, safety, reliability, and other vehicle-related aspects represents a great challenge for the automotive industry. Being an important segment of the hybrid technology, Hydraulic Hybrid vehicles have been increasingly drawing attention from researches and automotive manufacturers all over the world.

Hydraulic accumulators are characterized by higher power density and the ability to sustain high rates and high frequencies of charging and discharging, both of which are not yet achievable by electrochemical storing devices. By providing extremely high power density, the hydraulic hybrid concept is very well suited to all types of vehicles undergoing frequent stopping and starting phases, such as buses circulating in urban traffic conditions. Such driving conditions significantly affect the fuel economy and pollutants emission. Energy stored in the hydraulic accumulator can be used during vehicle acceleration, or to assist or replace the combustion engine at unfavourable operating points.

The Hydraulic Hybrid system has the potential for improving fuel economy by operating the engine in the optimum efficiency range and by harnessing the vehicle's deceleration energy. Hydraulic Hybrid vehicles may employ hydrostatic transmission instead of commonly used mechanical transmission, eliminating the mechanical connection between the engine and the driving wheels [1, 2], thus increasing the control possibilities.

In this paper, an introduction regarding the hydraulic hybrid technology concept is presented, along with the most important aspects of its operation. Expected and measured fuel economy improvements obtained from research efforts around the world are further introduced. Then, results of the initial study of data acquired in real-world driving conditions of a transit bus circulating in Belgrade's transportation system in different traffic and occupancy conditions are laid out. This analysis permits assessing the potential fuel economy benefits that could be achieved by implementing a hydraulic hybrid powertrain.

2 HYDRAULIC HYBRID TECHNOLOGY CONCEPT

The single, most significant mechanism responsible for energy efficiency increase in a hydraulic hybrid system is based on regenerative braking (RB) technology, whose task is to convert the vehicle's kinetic energy and store it in hydraulic form. This energy would normally be wasted as a heat emitted to the environment from the braking system. During vehicle acceleration, the stored energy is fed into the traction drive to relieve the IC Engine, as a prime mover, or to significantly improve its torque characteristics.

The basic architecture of a hydraulic regenerative braking system is similar to that of an electric hybrid, connecting the additional energy storage device and converter to the existing drivetrain with the IC Engine. However, different characteristics of the individual components used in electric and Hydraulic Hybrids result in different potentials for fuel consumption improvement. These differences primarily arise from capabilities of energy storage devices used in electric (EH) and Hydraulic Hybrids (HH).

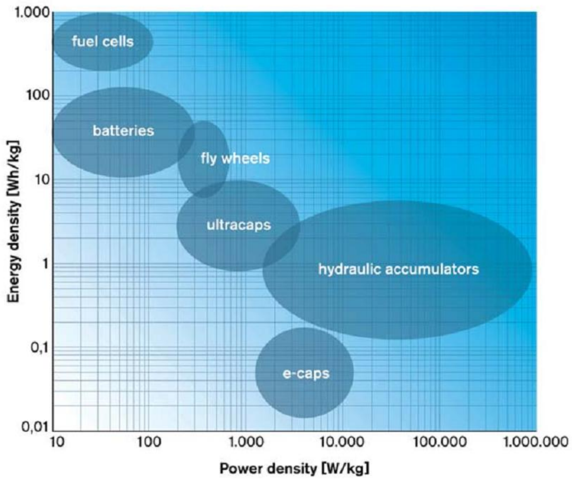


Figure 1: The Ragone plot ranks various energy storage devices by their energy and power density [3].

Batteries used in electric hybrids are distinguished by their ability to store considerable amounts of energy at a relatively slow rate. The disadvantage being that, for reasonably sized batteries, they are unable to accept significant braking power due to their low power density and high internal resistance. Because of this, electrochemical devices are presently unsuited for delivering the amount of power needed for accelerating heavy-duty vehicles.

On the other hand, hydro-pneumatic accumulators used in Hydraulic Hybrid powertrains offer a significantly increased power density. The generated braking energy can be accumulated completely even on large mobile machines and commercial vehicles and under strong braking conditions. Hydraulic accumulators, however, suffer from a relatively low energy density. Reasonably sized hydraulic storage devices are able to efficiently store braking energy, but continuous storage of excess IC Engine power is limited. The Ragone plot in Figure 1 illustrates the power vs. energy relationship of different energy storage devices. The underlying differences in characteristics of hydraulic and electric types of energy storage devices are responsible for radically different optimal control strategies.

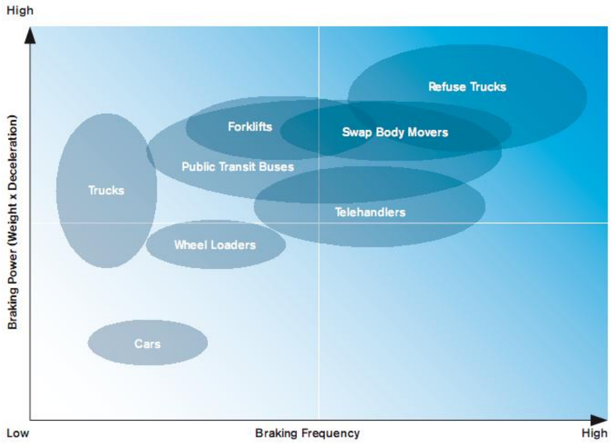


Figure 2: Influence of vehicle mass and driving cycle characteristics on RB potential [4].

Vehicles with high starting and stopping torques, i.e., high braking and acceleration forces, such as city buses can take the full advantage that the hydraulic hybrid concept brings. Electric Hybrids' focus, on the other hand, is on raising the load point of the IC Engine and to store the continuously generated energy for use in a purely electric traction drive or for covering peak power needs. The EH concept thus has limited suitability for driving conditions involving frequent and cyclical starting and stopping phases, since they involve large amounts of braking and acceleration forces. The Hydraulic Hybrid excels in quite different circumstances: the power from the braking process is reused in the following acceleration phase. Since the hydraulic hybrid regenerative braking system (HRBS) stores the vehicle's kinetic energy, benefits are amplified with increased vehicle mass and deceleration (braking power) and with increased braking frequency (Figure 2).

Comparing the overall regenerative braking efficiencies attained with the implementation of these two hybridization concepts, it can be clearly said that the advantage is on Hydraulic Hybrid's side with figures showing that more than 60 % of energy harnessed during deceleration can be returned into the next acceleration phase (Figure 3). The lower individual machines' efficiencies, and in particular the inability of the battery to store energy at high rates, are responsible for the significantly lower RB efficiencies attained with the EH concept (less than 20 %, Figure 4).

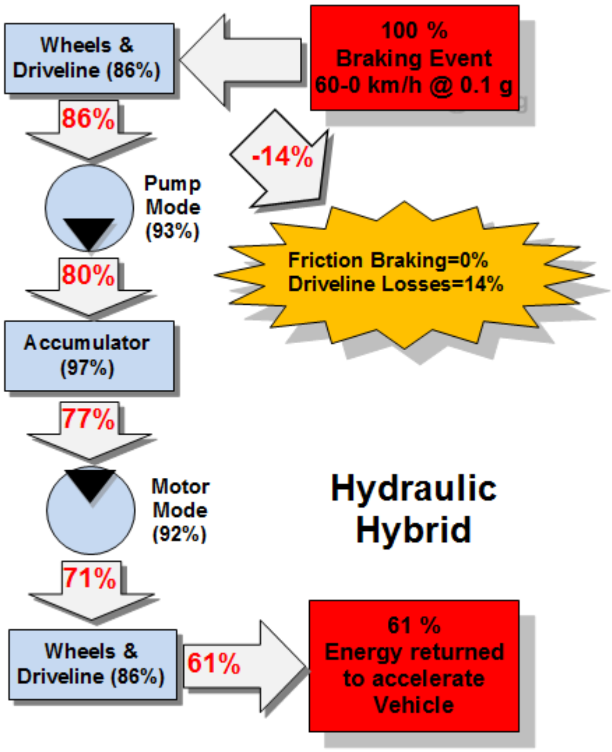


Figure 3: Overall regenerative braking energy efficiency of a hydraulic hybrid concept [5].

With regard to considerations relating to the exact configuration of the hydraulic hybrid system elements in a vehicle's drivetrain, two basic arrangements are possible: parallel and series hybrid.

In a parallel Hydraulic Hybrid (Figure 7), the conventional vehicle driveline is supplemented by the hybrid system. It is designed for vehicles having a conventional mechanical drivetrain and an IC Engine as the primary drive. When braking, a gearbox connects the hydraulic pump to the mechanical drivetrain to convert kinetic into hydraulic energy stored in the high pressure accumulator. During acceleration, the entire process is reversed: the pressurized fluid in the accumulator is allowed to be discharged and flows back through the hydraulic pump, which now acts as a motor, transferring its energy to the mechanical drivetrain. Modular construction means that the parallel Hydraulic Hybrid system gives unique advantages of easy and cost-effective implementation in current production vehicles. It also represents a convenient aftermarket solution for vehicles already in service. Parallel hybrids represent a compromise where the potential for maximum efficiency is sacrificed for cost effectiveness and ease of implementation, achieving fuel savings of approximately 20-40 % [5]. For that reason, parallel hybrids are commonly known as “mild hybrids”.

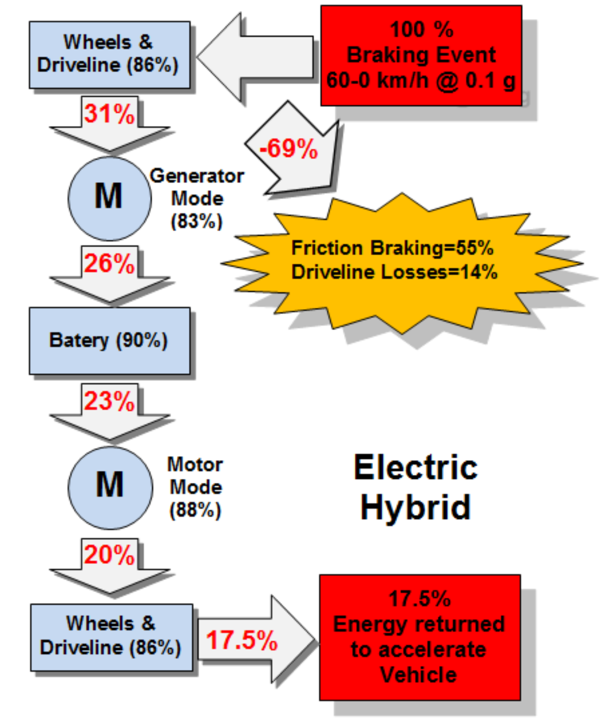


Figure 4: Overall regenerative braking energy efficiency of an electric hybrid concept [5].

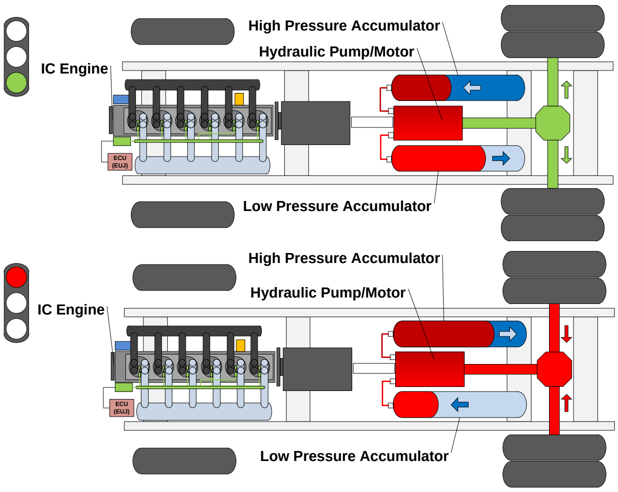


Figure 5: Hydraulic Hybrid Regenerative Braking phases.

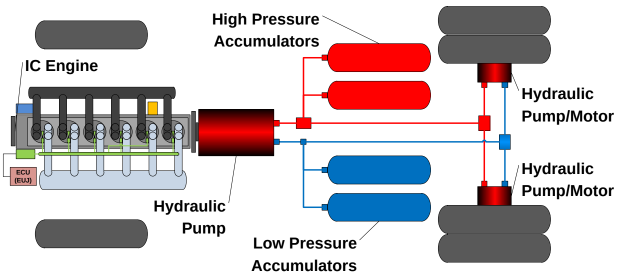


Figure 6: Series Hydraulic Hybrid configuration.

The full potential of the Hydraulic Hybrid concept can be achieved in a series hybrid configuration. A series Hydraulic Hybrid power system combines an IC Engine and a hydraulic propulsion system to replace the conventional drivetrain and transmission. The entire power to the drive wheels is transferred by means of pressurized fluid. The vehicle uses hydraulic pump/motors and hydraulic storage tanks to recover and store energy. It allows the IC Engine to operate with higher efficiency by moving the operating points toward higher brake mean effective pressures. The vehicle recovers and stores energy in practically the same way as Parallel Hydraulic Hybrid vehicles do. Even though hydraulic components create more losses compared to the conventional mechanical transmission elements, these losses are offset by the energy that is recuperated during braking phases. Powertrain control possibilities are maximized.

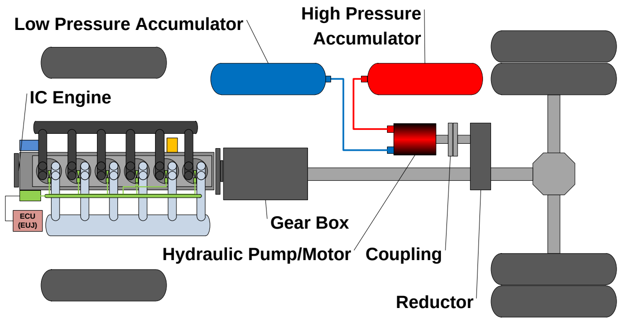


Figure 7: Parallel Hydraulic Hybrid configuration.

3 ANALYSIS OF HYDRAULIC HYBRIDS’ POTENTIAL BENEFITS

Utilizing Hydraulic Hybrid technology only for regenerative braking purposes can lead to fuel savings of up to 25 % [3, 6, and 7]. Corresponding reduction in CO_2 emissions is an additional benefit. The acceleration response, allowed by hydraulic power assist, can be improved by as much as 25 % (0-50 km/h [8]).

In a Series Hybrid Hydraulic System, the demonstrated fuel economy improvement is significant (fuel savings of approximately 60-80% [5, 6] are achieved).

HHT Concept	Fuel efficiency improvement
Baseline vehicle	–
Hydraulic Hybrid Engine always running	39-44%
Hydraulic Hybrid Engine-off when vehicle not moving	52-59%
Hydraulic Hybrid Engine-off when vehicle decelerating or not moving	70-74%

Table 1: Improvements in fuel economy with different HHT concepts and control strategies [7].

An experiment consisting of simultaneous logging of J1939 CAN powertrain parameters and GPS tracking data was conducted on a transit bus in Belgrade. The bus line in question was the number 65, connecting Novi Beograd and Zvezdara municipalities. This has allowed us to obtain the driving cycle of a bus circulating in real traffic and occupancy conditions, permitting us to proceed with fuel consumption calculations involving alternative powertrain configurations, and in particular the hydraulic hybrid system.

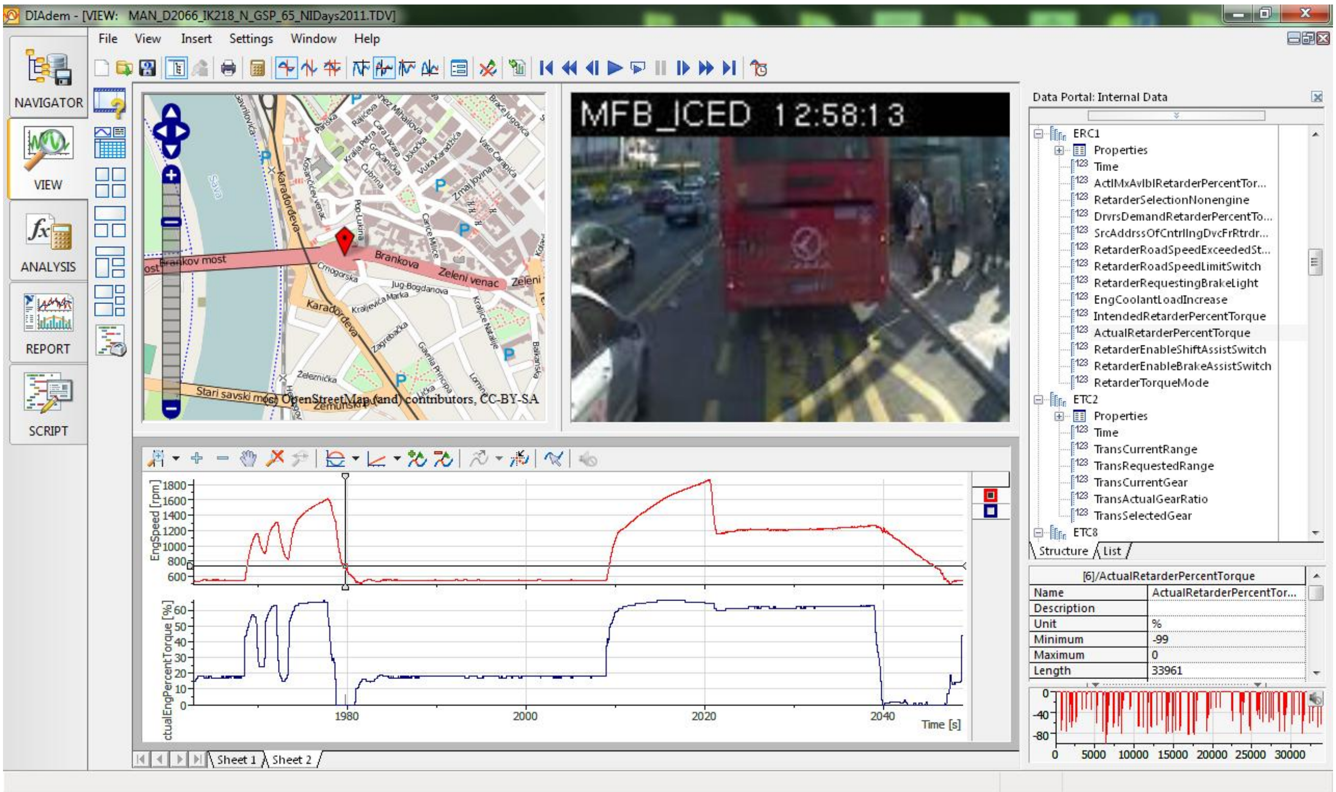


Figure 8: Analysis of logged data.

		Driving cycle 1 start: 06:03:15	Driving cycle 2 start: 13:10:35	Driving cycle 3 start: 15:11:09
Effective Engine Work	[MJ]	272.2	263.1	248.4
Deceleration Energy	[MJ]	122.3	123.8	106.9
Total Fuel Consumed	[l]	20.0	20.0	18.7
CO_2 Emissions	[kg]	53.4	53.3	50.0
Trip Time	[s]	5962	6731	6823
Deceleration/Engine Work Ratio	[-]	0.45	0.47	0.43
Energy Savings Potentials	**[%]**	**27.0**	**28.2**	**25.8**
CO_2 Emission Reduction Potentials	**[kg]**	**14.4**	**15.0**	**12.9**

Table 2: Initial energy analysis based on data acquired during the experiment.

		Driving cycle 1 start: 06:03:15	Driving cycle 2 start: 13:10:35	Driving cycle 3 start: 15:11:09
Total fuel consumed	[l]	20.0	20.0	18.7
Fuel consumed during stops	[l]	3.75	3.79	4.17
Percent of fuel consumed during stops	**[%]**	**18.8**	**19.0**	**22.2**
Fuel consumed at bus stops	[l]	1.93	2.22	1.70
Fuel consumed due to traffic stops	[l]	1.83	1.58	2.47

Table 3: Analysis of fuel consumption when bus is stationary.

The experiment was conducted on an Ikarbus IK218N, equipped with a MAN D2066 LOH1, 10.5 l, 6-cylinder, turbocharged diesel engine and a Voith 864.5 transmission. A single driving cycle consists of a complete run from Zvezdara to Novi Beograd and back to the starting point (Zvezdara). Results of the initial analysis of data gathered during the experiment are shown in Table 2.

The effective engine work calculation is based on the actual percent torque and friction percent torque data channels that are accessible on the J1939 bus. Values of up to 272 MJ per complete driving cycle are achieved.

The maximum value corresponds to the shortest trip time, meaning that the higher vehicle speeds achieved due to less congestion are correlated with the effective energy delivered to the drivetrain.

The deceleration energy is calculated under the assumption of constant vehicle mass of 23000 kg and accounts only for decelerating periods with fuel cut-off or braking states on. Values up to 124 MJ are obtained, representing nearly 50 % of energy transferred to the vehicle. The minimum value is encountered during the third run, which is associated with the maximum trip time. Because the vehicle speeds are significantly lower than during other runs, the braking energy is also diminished. However, even during this run, the deceleration/engine work ratio is greater than 40 %, which represents a great energy recovery potential.

The total fuel consumed, along with the CO_2 emission, is calculated by integration of the fuel rate data available on the J1939 bus.

The estimated energy savings parameter is based on the assumption that 60 % of the deceleration energy can be reused to accelerate the vehicle. Values range from 25.8 to over 28 %.

It can be said that, regardless of traffic and occupancy conditions or the driving cycle's road profile, more than 20 % of fuel can be saved with the implementation of a Hydraulic Hybrid Powertrain. Bearing in mind that 100000 kg of fuel is used by Belgrade's transportation system on a daily basis, this worst-case scenario fuel reduction figure shows that huge amounts of savings can be achieved: over 30000 € could be preserved each day, effectively containing the payback period of a single vehicle to no more than 5 days. The payback period of a single, HHT-equipped bus is approximately 5 years (for a completely new vehicle, not taking into account predicted savings in brake system maintenance costs). Considering the daily fuel consumption of the transportation system, a significant reduction in CO_2 emission in excess of 60000 kg per day can be achieved.

Another possibility for a viable fuel efficiency improvement lies in periods during which vehicles are at bus terminuses, where turning occurs. It has been determined that the mean time a vehicle spends at a terminus is approximately 8 minutes. The minimal idle fuel consumption rate of the bus considered during this experiment is 4.3 l/h, which means that over 0.57 l of fuel is consumed during these events. Bearing in mind that over 20 turning events occur for a bus circulating on line 65, over 11 l of fuel could be preserved per day and per vehicle if a start-stop system is implemented. It should be noted that engines are presently being held turned on because of problems frequently encountered when restarting.

Analysis on data acquired during the experiment to quantify fuel consumption for periods of time during which the bus was stationary has yielded interesting results (Table 3). Indeed, it is concluded that more than 18 % of the total fuel consumed during a driving cycle is spent while the vehicle isn't moving. This percentage ranges from 18.8 % to 22.2 % while covering driving cycles for which substantially different occupancy and traffic conditions were encountered. This represents a significant potential for fuel consumption reduction. A start-stop system capable of sustaining critical vehicle accessories while the engine is turned off could bring pronounced economy benefits.

Engine auxiliaries, such as cooling fan, alternator, A/C, engine oil and coolant pump consume more than 10 % of nominal engine power. Through implementation of hydraulic motors for powering these devices, the overall efficiency could be improved by using stored hydraulic energy. Auxiliaries can be downsized and optimized since they can run at given speed, independently of the engine's speed. They can also be driven by a single, engine-powered hydraulic pump.

According to Eaton [5], capturing 70 % of braking energy via hydraulic fluid can reduce brake wear by more than 50 %. Public transportation vehicles generally require intensive brake system maintenance. Savings accomplished through brake system maintenance reduction only are comparable to 50 % of HH system implementation costs (for low volume production). Besides maintenance costs, reduced brake wear has favorable effect on the environment with reduced emission of fine dust particles from brake pads.

The only clear advantage Electric Hybrids have over Hydraulic Hybrid technology, regarding the implementation on transit buses, is related to noise levels of the corresponding components. Noise generated by hydraulic components is mainly influenced by their number and design aspects (parallel, series concept). However, efforts made by research institutions in the field of hydraulic component development and design have led to new solutions with significantly improved noise and vibration characteristics in recent years [9, 10].

Beside the high potentials for fuel economy and exhaust emission improvements, Hydraulic Hybrids offer the lowest incremental costs among all hybrid concepts. The estimated costs for retrofitting a transit bus to full Hydraulic Hybrid specifications range between 30000 and 40000 €. Further development of hydraulic components, designed specifically for hybrid drive use, and their massive production and implementation, is predicted to lead to significant initial costs reduction (up to 75 %).

4 CONCLUSIONS

The characteristics of the components used as part of the Hydraulic Hybrid concept, namely, the high power density of the hydro-pneumatic accumulator and the pump/motors, along with high efficiencies, make it ideally suited for implementation on transit buses. Developed and tested prototypes and demo platforms have demonstrated significant performance improvements in terms of fuel economy (up to 60 %) and pollutants emission reduction. The energy balance analysis of data acquired during an experiment conducted on-board a transit bus circulating in real traffic and occupancy conditions agrees well with figures obtained from other research teams around the world. However, further efforts concerning the integration of hydraulic components in vehicle's powertrain and braking systems will be of crucial importance for bringing this technology beyond the concept demonstration level. In order to achieve this, special attention has to be paid to the following challenges:

- Adapting the industrial pump/motor technology to automotive applications.
- Minimizing the pump/motor noise levels.
- Reducing the cost of composite accumulators.
- Familiarize the end-users with this technology's benefits, reliability and safety aspects.
- Implementing stimulating tax credits for hybrid vehicles in order to encourage their large-scale commercialization.

5 REFERENCES

[1] Hui, S., 2010, Multi-objective optimization for hydraulic hybrid vehicle based on adaptive simulated annealing genetic algorithm, Engineering Applications of Artificial Intelligence, 23, 5, pp. 27-33

[2] Hui, S., Ji-Hai, J. and Xin, W., 2009, Torque control strategy for a parallel hydraulic hybrid vehicle, Journal of Terramechanics, 46, 6, pp. 259-265

[3] Kliffken, M., Beck, M., Ehret, C. and Stawiarski, R., 2009, Put the Brake on Costs and Preserve the Environment with Hydraulic Hybrid Drive, ATZoffhighway 1, 3

[4] Hydraulic Hybrids from Rexroth: Hydrostatic Regenerative Braking System HRB, http://www.boschrexroth.com/country_units/america/united_states/sub_websites/brus_brh_m/en/markets_applications_jg/a_downloads/ra98310_2010-08.pdf

[5] Wendel, G., 2007, Hydraulic Hybrid Technology Review

[6] Gray, C.L., 2006, Hydraulic Hybrids: EPA Hydraulic Truck Initiative, U.S. Environmental Protection Agency, Houston, Texas, USA

[7] Gray, C.L., 2007, Hydraulic Hybrids: Demonstration for Port Yard Hostlers, U.S. Environmental Protection Agency

[8] Kepner, R.P., 2002, Hydraulic Power Assist − A Demonstration of Hydraulic Hybrid Vehicle Regenerative Braking in a Road Vehicle Application, International Truck & Bus Meeting & Exhibition, Detroit, MI, USA, SAE 2002-01-3128

[9] Wendel, G. and Jackson, T., 2006, Balance of Power, Technology Today, 27, p. 32

[10] Innas - Floating Cup, http://www.innas.com/FC.html

Performance Oriented Building Assessment: Time and Space the Two Dimensions of Sustainability

C.Gargiulo[1]

[1]B.E.S.T. Department of Building, Environment, Science & Technology,
Politecnico di Milano, Milano, Italia

Abstract

The new European standard family of *CEN TC 350* is expected to become a lever, leading the construction sector towards more sustainable goals and practices. On the other hand, to be effective, the harmonized standards need dealing with the existing national and local assessment and regulatory instruments. The identification of a *multiscale* strategy, applied to the “Leonardo da Vinci Sustainable Campus” in Milan, with respect to the *energy, environmental, social and economic performances*, involving the *stakeholders* in the decisional process, attempts to meet the conditions of the *space* and the needs of the current *time*.

Keywords:
sustainable management, multiscale, performance oriented standards, stakeholders, holistic approach

1 INTRODUCTION

The current *rating systems* for a *sustainable management* of construction works are not mandatory. The new European standard family of *CEN TC 350* is supposed to be as guidelines of the *performance oriented building assessment*.

The investments and the results from the on going research suggest to enhance the efforts, in the perspective of a new European Directive, that could work, likewise the EPBD (91/2002/CE Directive for the energy efficiency of buildings), as a lever not only to definitely lead the construction sector to more sustainable goals and practices, but also to give a new social answer and an impulse to the market, collecting the requests, the urgent needs and the suggestions from the *stakeholders*. At the same time, to be effective, the harmonized standards need to deal as much as possible with the environmental national and local regulations and governance instruments, in a *multiscale* perspective.

In this vision, *time* and *space* need to be, in short, the two central points for any optimized application.

The paper reports on the on going research focused on the development of inductive, logical / operational guidelines, aimed at optimizing the sustainable management of construction works.

The identification of a *multiscale* strategy, applied to the “Leonardo da Vinci Sustainable Campus” in Milan, with respect to the energy, environmental, social and economic performances, aims at finding and using key *objectives / criteria / indicators*.

The *holistic approach* and the involvement of the *stakeholders* in the method, supported by Multiple Criteria Decision Making (*MCDM*) models and methods, features the time and space perspective to give transparent answer to the search of the best technical solutions and strategies, but also of a *shared value* in a large sustainable conception.

2 FRAMEWORK AND PERSPECTIVES OF ASSESSSMENT TOOLS

2.1 The sustainability assessing systems: tools to enhance

Worldwide are considerable the resources and efforts that the public authorities, universities, research institutes, firms, institutions of standardization are investing to improve the methodologies and tools for assessing the sustainability of buildings and operations. These include in particular the European Commission, investing resources on several projects aiming at the harmonization of the different systems (EN TC 350 Standards, Open-House, Super Buildings, etc.).

The current systems (Leed, Dgnb, Itaca, Breeam, etc.) are not mandatory, nor the harmonized standards are expected to be. At most, they are required for the implementation of specific governmental plans or to access to such economic incentives.

Further efforts are needed to ensure that the assessment systems, guidelines for the sustainable works, could be valorised and become a lever for a real sustainable development of the Member Countries.

2.2 The parallel with the energy sector: the potential

The 91/2002/CE Directive for the energy efficiency of buildings (along with other measures such as for the development of photovoltaics and other), even in the face of predictable difficulties in implementation in different realities, is bearing fruit in reducing climalterant emissions and the increasing of independence from non-renewable energy sources, including the dissemination of a common culture in favor of environmental protection.

The Directive has played well, from the beginning, on a tool, the energy label, in the wake of the pilot appliances, created to leverage the real estate market in favor of a new supply and demand for buildings to a lower energy impact. The implementation of the Directive has stimulated complementary and virtous actions in many EU Countries targeting the same objectives.

Among the most successful programs, are the German Federal and local economic incentives and the system of tax deduction (55%) for energy saving refurbishments still in force in Italy. These operations not only produced a trend of improvement in energy demand, but they have triggered virtous processes for the economy, both in favor of the construction companies and the suppliers of innovative materials, products and technologies.

Taking example from the virtous experience of the EPD, it seems reasonable the implementation of a sustainable building management system having a similar potential, as a lever for the environment reduction of resource use / emissions and energy consumption associated with the processes, as a social lever for the achievement of the objectives of democracy and civil development in Europe, as an economic recovery thanks to a new impulse to the construction sector.

2.3 Performance management as a strategic support for sustainability, towards a possible European Sustainability Performance Directive

The indicators to be considered 'strategic' must belong to a vision of continuous improvement and comparison of alternatives.

On the concept of continuous improvement and rising targets in parallel with the implementation of an innovative procedure, are based the current European Directives such as the EPBD (2002/91/CE) which, although recording physiological difficulties of implementation throughout the European countries, in 10 years has led to the setting of objectives unthinkable at the beginning: building on near-zero energy consumption.

One wonders then how come we can not, on the lines, also seen investments made through the last framework programs, promoting the adoption of a directive which gives guidelines for the evaluation and certification of the level of sustainability of buildings, showing definitely a new way to build new and upgrade existing buildings. And thus effectively directing a building production in terms of resources / energy saving, as well as enshrining the values of the optimization, the reuse and the flexibility of the buildings.

Will help the decision making and quality improvement theories and methodologies, in particular: Benchmarking, Rating and Ranking for the identification of reference standards and the classification of possible alternatives.

3 THE METHOD

3.1 Overview

The title of the on going research is 'Sustainable management of construction works from the building to the context'

Purpose

Development of inductive, logical / operational guidelines, aimed at optimizing the sustainable management of construction works, as a contribution to the methods / guidelines for the management of sustainability in constructions, aiming to support a decision-making process (public and private managers, planners, developers, policy makers) with the involvement of the Stakeholders.

Case study

"Sustainable Campus" is an international multi-disciplinary project, focused on the energy-environmental-social up-grading of the Italian University Campus Leonardo (Politecnico di Milano and Università degli Studi di Milano) and its neighborhood

http://www.campus-sostenibile.polimi.it/index.html?request_locale=en

Goals

Identification of a multiscale operative strategy applied to the different phases of the construction process, aimed at improving energy, environmental and social performances, with respect to the building, the urban and the neighborhood context, helped by the setting of key indicators (environmental, economic, social) and the involvement of a wide range of representative stakeholders, both social groups and supply chain operators, asking their points of view and data.

4 THE CONCEPTUAL MODEL

4.1 Steps and stages

The conceptual model in Fig. 1 shows the flowchart from the input to the specific outputs. The first input is given by the methodologies and related criteria / indicators existing / under construction at the different scales.

The analysis of the possible interrelations (overlaps, similarities, but also different or conflicting) between the existing panels gives some general outputs.

The analysis of the Case study and its specific needs and processes leads the second stage of the procedure, aiming to select a panel of Criteria / Indicators amongst the many Criteria / Indicators included in the input sets.

The set is submissed to some selected Stakeholders with the aim to obtain their structure of preferences, and even to test their level of awareness of the priorities represented by the sustainable Criteria / Indicators.

The research is still on going but some considerations are already be done.

5 THE DISCUSSION

5.1 Management system: from global to local

In a harmonic overall vision, the consistency with relevant programs and values that form the frameworks of the European urban development must be ensured.

Declined in various forms (plans and frameworks) by the European Institutions, remain as the cornerstones of the European urban-development: the "Leipzig Charter on Sustainable European Cities" (2007), elaborated on the document of the EU Sustainable Development Strategy, and Agenda 21 Action Plan (principles, models and indicators).

The harmonized systems that are under development unify under one umbrella, made of shared objectives and instruments from an European perspective, the management of sustainability.

Do not forget, however, that the application in different contexts and by different parties can not fail to take account of local factors, such as the availability and accessibility of resources and materials, the characteristics of the fabrics and manufacturing districts, the features of the markets, the local building traditions, the specific social and economic emergencies.

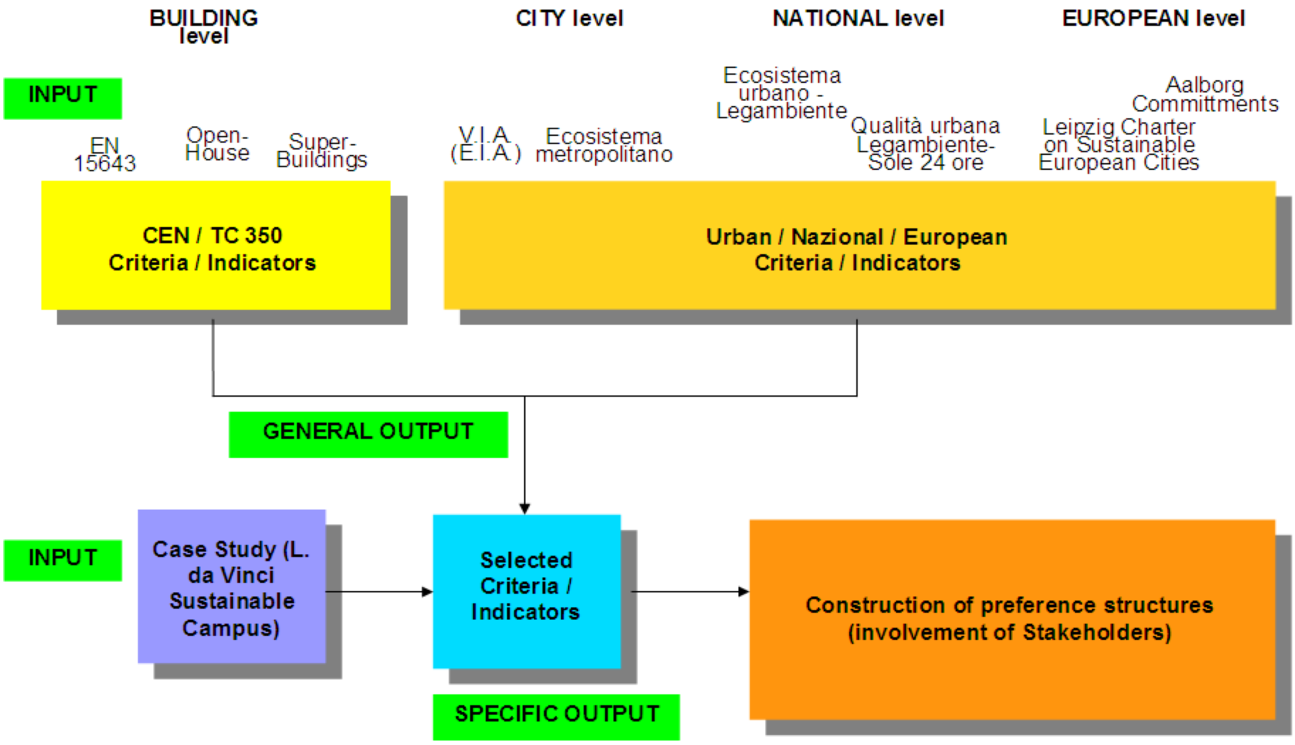


Fig. 1: The conceptual model of the Method

In this perspective, standards can be general Guidelines, which would become more effective in terms of overall outcome as more and more locally implemented and synergically linked to such existing instruments.

This needs dealing as much as possible with the procedures for surveying, planning, monitoring, incentiving, at the wide, intermediate and local scales set up.

And so we speak, with respect to countries (eg Germany has launched them) of national energy plans, renovation programs, but also of the Covenant of Mayors, local energy and mobility programs, etc.. With respect to Italy we talk about municipal building regulations, regional plans and actions, tax deductions for energy saving projects, and evaluation and monitoring systems of local policies, after many years become conventional (eg annual survey on the quality of life in the Italian cities by Sole 24 Ore - Legambiente, Urban Ecosystem by Legambiente, the Milan Metropolitan Ecosystem Reporting), but also social accountability balances, specific regional plans, Environmental Impact Assessments procedures, local Agenda 21 Action Plans.

The Fig. 2 shows an overview of the assessment / reporting / tools, systems and programs analysed in the case study.

A possible synergistic integration of all this tools and instruments would also enable the optimization of investments, especially in the situations of scarcity of resources and financial aids.

5.2 From certification to leverage in the real estate market under the pressure of stakeholders

An approach that intends to enhance the sustainability management tools as instruments to guide the present and the future of the construction sector can not fail to take into account constraints due to current factors of time in which operating.

These are factors that act in the form of laws, regulations, market trends, in response to pressure from stakeholders: policy makers, institutions, citizens, professionals of the construction industry. These players, who at other times have strongly driven the development, today are the ones most directly affected by the upheaval caused by the global and widespread economic crisis.

But even those who, as happened in other historical periods, have potentially greater room for the resumption thanks to the large capital reserve owned in terms of know-how.

And that is especially proper of such segments of the market (just think of the companies producing the most advanced technologies), having nature of versatility and capacity for renewal as well as human resources and equipment for research and development.

Similarly, all those supply chains that over the years have re-oriented themselves towards more environmentally friendly materials and technologies both in terms of savings in the use of natural resources and energy.

An approach to the tools for managing and enhancing the sustainability of construction works must contact and involve the Stakeholders, meaning both the social groups as users and the actors belonging to the building process i.e. the construction supply chain.

From a large economic point of view, the investors, the builders and the manufacturers are the actors for collecting requests and suggestions, so to transform the assessment tools from 'constraints' into opportunity, as medium-long term levers on the market above mentioned. So, in a way not unlike that activated in the energy sector and through the energy certification system, hand in glove tied field to the building.

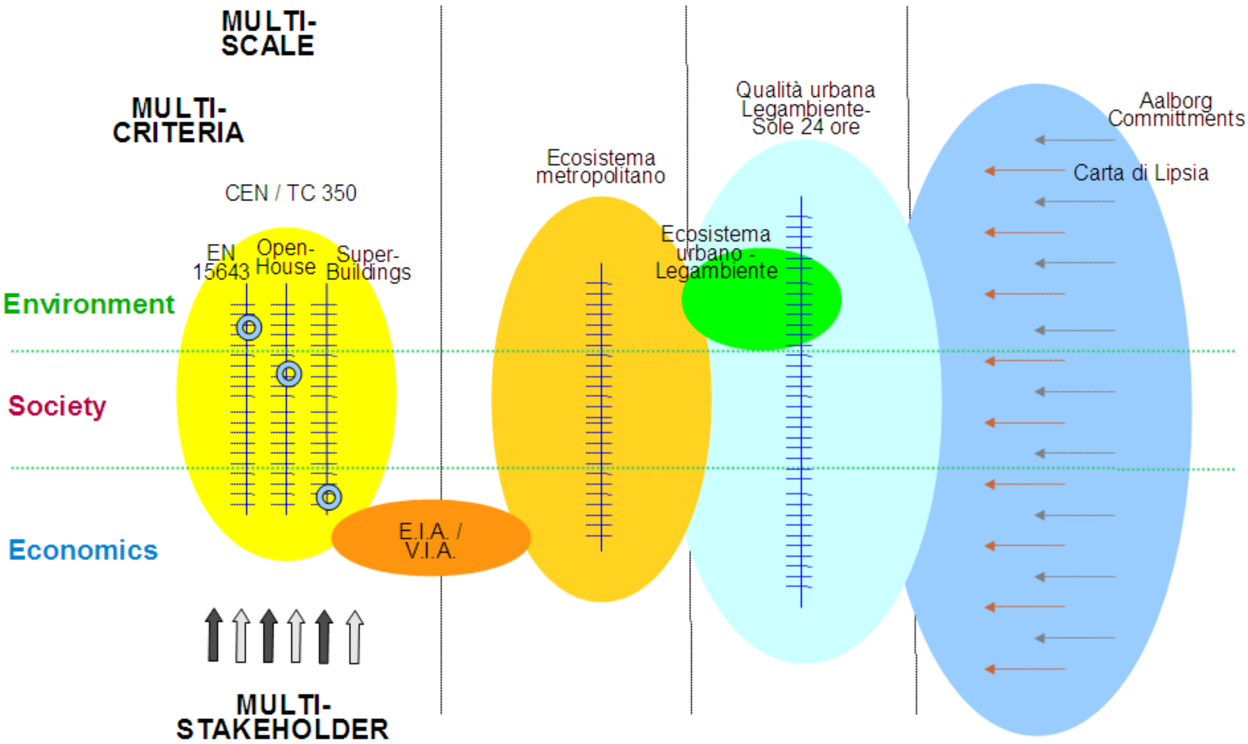


Fig. 2: Multi-Criteria, Multi-Scale and Multi-Stakeholder Approach

6 CONCLUSIONS

The *Multi-criteria* point of view given by the Working Groups featuring the new European standard family of *CEN TC 350* for the assessment of sustainability in construction works, to be actually effective, needs in practise to be replied from the general to the detailed level. This means at first to analyse if are available any evaluation systems at national and local level.

If existing and validated, to outline a consistent framework of Methodologies, Criteria and Indicators. In base of the needs and the suggestions of the single case study / opetation a screened panel must be shared and validated involving the Stakeholders into the decision-making process. Their participation gives assurance of actuality and compliance with the *needs of the time*, as well gives the start to the virtous process in the markets for more sustainable drives and pressures in the construction sector and the affected national economies.

The *Multi-scale* modeling supports the decison makers addressing these challenges at organizational, temporal and *spatial scales* and showing that *Time and Space are the two essential dimensions of Sustainability*.

7 REFERENCES

Daniotti, B., 2012, Durabilità e manutenzione edilizia, Editore UTET scienze e tecniche, Torino

Daniotti, B., Re Cecconi, F., 2010, Test methods for service life prediction, CIB

Masera, G., 2004, Residenze e risparmio energetico – Tecnologie applicative e linee guida progettuali per la costruzione di abitazioni sostenibili, Il Sole 24 Ore, Milano

Palazzo, D., Masera, G., Grecchi, M., Malighetti, L., Sesana, M., International Journal for Housing Science and its Applications (ISSN: 0146-6518), 35/1:11-21

Bruglieri, M., Ciccarelli, D., Colorni, A., Lué, A., 2011, PoliUniPool: a carpooling system for universities, 14th Meeting of the Euro Working Group on Transportation, Poznan

Capello, R., 2007, Regional Economics, Routledge, London

Camagni, R., Capello, R., Chizzolini, B., Fratesi, U., 2008, Modelling regional scenarios for the enlarged Europe, Springer, Berlin

Ginelli, E., 2010, Caratteri e potenzialità per il costruire contemporaneo, in Bosio, A., Sirtori, W., Abitare. Il progetto della residenza sociale fra tradizione e innovazione (ISBN: 9788838757648), Maggioli: 135-147

Lavagna, M., 2008, Life cicle assessment in edilizia. Progettare e costruire in una prospettiva di sostenibilità ambientale, Hoepli

Campioli, A., Eco-towns. Energia, ambiente e paesaggio per nuovi modelli di sviluppo urbano in Trasporti & Cultura (ISSN: 1971-6524), 10(26): 52-59

Antonini, E., Giurdanelli, V., Zanelli, A., 2010, Reversible Design: Strategies to Allow Building Deconstruction and a Second Life for Salvaged Materials, in Second International Conference on Sustainable Construction Materials and Technologies, Università Politecnica delle Marche, Ancona, Italy, 1207 - 1217

Ilomäki, A., Lützkendorf, T., Trinius, W., 2008, Sustainability Assessment of Buildings in CEN/TC350 Sustainability of Construction Works, Proceedings of the World Conference SB08 (ISBN 978-0-646-50372-1)

Lützkendorf, T., Lorenz, D.-P., 2006, Using an integrated performance approach in building assessment tools in Building Research & Information, 34(4): 334–356

Salat, S., Bourdiv, L., 2011, Factor 10: Multiplying by 10 resource productivity in the urban world, SB 11 World Sustainable Building Conference, Helsinki

ENSURING SOCIAL COHESION – CITIZENS AS PLANNERS OF URBAN GREEN SPACES

Amila Brajić, Senka Mutabdžija, Bruno Marić, Mersudin Avdibegović, Sabina Delić, Dženan Bećirović

[1]University of Sarajevo, Faculty of Forestry, Zagrebačka 20, 71000 Sarajevo
Bosnia and Herzegovina

Abstract
Urbanization in transitional societies, together with the fast way of living, is very often the reason why modern human beings are completely or partially isolated from the nature. To ensure complete fulfilment of urban green spaces` functions, these spaces need to be harmonized with the preferences of their final beneficiaries. The goal of this paper is to demonstrate how implementation of participative, multidisciplinary and integrative approach can improve planning and managing process in urban green spaces which should lead to their better functionality. It is expected that results of this paper should be used as recommendations for improvement of functionality of urban green spaces in city of Sarajevo.

Key words:
Social Cohesion, Green Classrooms, Urban green spaces

1 INTRODUCTION

It seems that, in the history of Sarajevo, every childhood was marked by the very close relationship with the nature. Nowadays, Sarajevo is unfortunately facing with the numerous problems related to the urban greenery. Reasons are manifold while the drivers for unfavourable situation of the urban greenery are ranging from intensified migrations from rural to the urban areas to various irregularities related to the civil engineering. One thing is for sure - negative impacts of this situation have direct or indirect influence on entire population of Sarajevo.

The urban demographic situation across the world is putting the environmental sustainability of cities and the well-being of their inhabitants at stake. The intensification and expansion of cities without consideration of the land-use capacity and local needs for green environment, recreation, and other benefits from forests have contributed to a drastic depletion of tree and forest cover within and around cities. Certainly, this is common in developing countries and countries with economies in transition, where the negative effects of unplanned urbanization and a weak institutional framework are exacerbated by natural disasters, conflicts and war [1]. The Food and Agriculture Organization of the United Nations (hereinafter FAO) considers that urban and peri-urban forestry are significantly contributing to the improvement of environment and livelihood of vulnerable populations in and around cities. Trees and forests are an essential part of urban development that contribute to vibrant cities, public health, and functioning ecosystems and watersheds, while mitigating risks of floods and landslides [1]. Therefore, the major challenge is to ensure recognition of the strategic importance of trees and forests in urban development. Awareness of the society about the importance of healthy environment should be translated into adequate national and local policies. In countries with economies in transition such as Bosnia and Herzegovina (hereinafter B-H), trees and forests are rarely taken into account in urban and peri-urban development programmes. While urban forests have been shaped by urban societies due to their changing power relations and demands, simultaneously urban spaces impacted these societies by becoming inseparable part of local culture and identity. Urban forests represent two contrasting yet supplementary concepts for analysing interactions between people and environment that are referring to the place and space: while place refers to home, familiarity and safety, space stands for the unknown, the wild, the adventurous [2].

The most effective way to ensure and protect urban green spaces is to create places such as parks and park-forest as well as small areas such as schoolyards. Most of the society thinks that the purpose of the urban green spaces is to make nice and comfortable life-environment. Certainly, urban greenery mostly has nonmaterial, spiritual functions such as decorative-aesthetic, sanitary-hygienic and cultural-educational [3]. According to Ljujić Mijatović, green spaces around schools belong to the category of special-purpose greenery. Their aim is twofold: to protect space around schools from outdoor negative effects and to ensure educative purposes so that children get familiar with different plants and acquire a habit of plants cultivation and nature protection. Moreover, greenery near educational institutions has irreplaceable role in spreading knowledge from the field of natural sciences to the children and youth as well as in understanding and ensuring interactions between human and nature, in general.

Different aspects of the urban greenery in Sarajevo have been the topic of research by several scientists. Of particular importance are researches related to dendrological specificities of urban greenery [4] [5], health condition of urban greenery [6] [7] [8], the issues related to spatial planning [9], valorisation and type of green spaces according to their functions, significance and position [10]. Destruction of urban and peri-urban greenery in Sarajevo during the last war (1992-1995) have been researched as well [11]. As one can conclude, most of the scientific and professional papers related to urban greenery in Sarajevo are focused on their biological and decorative functions. Sociological aspect of urban public greenery is rarely and/or narrowly covered in research or it is mainly focused on the sociological demands toward forests and urban forests [12] [13] [14]. Therefore, there is a significant need for the research that deals with the situations when children are end-users of urban green spaces. Lack of these researches significantly complicates the function of the institutions responsible for the urban planning as well as companies that are managing the urban public greenery. Actual concept of urbanism and necessity of human-nature interactions means fulfilment of human demands during the planning of urban green spaces. Therefore, purpose of this paper is to show how participatory, multidisciplinary and integrative approach can improve planning and managing of urban greenery which should lead to their better functionality.

2 MATHERIAL AND METHODS

The paper is based on the logic of participatory design characterised by users` involvement in design and management processes. The central idea of this approach is involvement of all stakeholders in design process in order to ensure that designed product meets the needs of all final users. The cooperation between designers/managers, researchers and stakeholders is essential in all stages of designing and management process. Therefore, this idea should be used in the designing process of urban green spaces in Sarajevo. This process involves following steps: appraisal, identification of the needs, restitution, organisation, planning, implementation and evaluation [15]. Participatory design is the initial step in the definition of common agenda by local community and an external entity or entities. It is expected that this initial step evolve for the parties concerned towards a self-sustaining development planning process at the local level [16]. To achieve the better usability of products, participatory design emphasizes co-research and co-design which means that designers/managers must come to conclusions together with final users [17]. Therefore, the main objective of this paper is application of participatory design methodology in processes of design and management of urban green spaces. The results of this paper are presented in form of case studies where methods of participatory design have been applied. In order to apply methods of participatory design, the scheme has been created based on three basic stages presented by Spinuzzi [17]. The scheme presented in Figure 1 is consisted out of several working steps starting from problem identification, three stages of participatory design and implementation of ideas created in joint efforts of experts and local stakeholders.

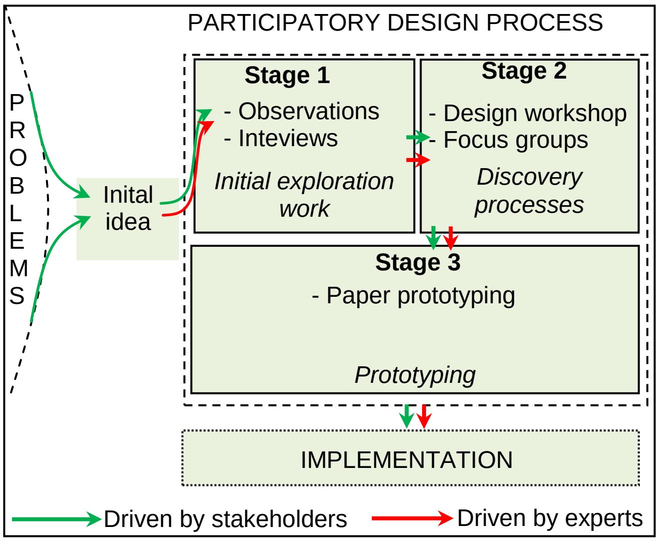


Figure 1: Phases of participatory design process

The starting point (initial idea) of the design process is, in most of cases, driven by local stakeholders and their efforts to solve some of the problems in local community. The second step is consultations with experts about identified problem and negotiation about the design-process. This is essential step for understanding local realities. Stage 1 (*"initial exploration work*") tends to implement research instruments such as observation, interviews with local stakeholders etc. Furthermore, cooperation among experts and stakeholders is main characteristic of stage 1 which should result with clear identification of further working steps and serve as introduction phase for stage 2. Spinuzzi states that *discovery processes* (stage 2) allows designers and users to clarify the users' goals and values and to agree on the desired outcome of the project. In order to specify needs of local stakeholders and create solid ground for development of final plans, design workshop or focus group can be applied in this stage. The results of cooperation in participatory design process are presented by stage 3 (*prototyping*). This is place where experts reveal their plans to stakeholders and present paper/plan emphasizing strong links between needs of local community and actual plans which are results of participatory planning and design.
The results of this paper are based on application of participatory design process on concrete case studies from Sarajevo. Two case studies are presented in this paper. The first case study is dealing with visitors´ demands toward the urban forest Vrelo Bosne. The second case study represents how authors, in cooperation with school managers, teachers and children, had created plan for the schoolyard. The design process of 'the green classroom' was initiated by school manager who had contacted authors and presented the problem of her school. As a result of this communication, an idea of having schoolyard that is appropriately arranged in order to fulfil all functions of green space around the school had arisen. The core idea of having these two case studies in the paper was to show how participatory design approach can be applied on two, totally different, urban green spaces categories by involving the final beneficiaries that are coming from two different social categories in order to fulfil their needs and ensuring social cohesion with the urban green space.

3 RESULTS

3.1 Case study: Urban forest Vrelo Bosne in Sarajevo

Vrelo Bosne is one of the oldest horticultural objects in B-H. Therefore, it has important place in national cultural-historical heritage. Vrelo Bosne has been protected since 2006, by Ministry of spatial planning and environmental protection of Canton Sarajevo. Total protected area is 603 ha. In accordance with Federal Law on Nature Protection, the area is proclaimed as Nature Monument which is equivalent to the third category of IUCN management category of protected areas [18].

Initial exploration work in Vrelo Bosne

Due to the modern lifestyle that characterizes Sarajevo, Vrelo Bosne has become the closest nature haven of its citizens where they usually seek for peace and tranquillity. Therefore, managing of this area implies understanding and respecting of visitors' demands. Idea of determination of visitors´ demands originated from the previous work of the author [14] (Brajić, 2011). The first step considered observation of the area and literature analysis on previous research. Appropriate questionnaire was designed by respecting few basic principles such as simplicity, user-friendliness and shortness. Questionnaire has 35 questions which are sorted in the following groups:

- Basic socio-demographic data about the respondents;
- Information about the visiting pattern of Vrelo Bosne;
- General questions about Vrelo Bosne;
- Attitudes toward Vrelo Bosne;

- Information about the possible negative impacts on the visitors and appropriate actions to prevent them.

Discovery processes in Vrelo Bosne

Data about visitors´ demands were conducted during the period 2009-2010. Proper research methods and tools were used in the process of data collection, analysis and interpretation of the results and deriving of the conclusions.

Qualitative and quantitative data, needed for analysis of visitors´ demands were collected by applying the method of face-to-face interview. It was estimated that, for the purpose of this research, sample size of the 300 respondents fully meets the defined confidence level and confidence interval. In order to ensure the representativeness of the sample in terms of social, demographical and economic characteristics of the respondents, special attention was devoted to the time and place of the survey-conducting. Method of random sampling was used in the selection of the respondents older than 15 years on the alley-area called Velika Aleja and park around the spring of the river Bosna. Since method of controlled random sampling was used, days and time of conducting the data were defined in advance. The obtained results were used to create policy directions for the management of the urban forest Vrelo Bosne.

Prototyping in Vrelo Bosne

Due to the purpose of this paper, following policy directions that are derived from the obtained results will be presented. These are as follows [14]:

- Creation of adequate measures for protection should be based on visitors´ demands and appropriate support measures;
- Minimisation of possibility for the conflicts among different visitors´ segments/groups through the organization and spatial planning processes;
- Identification of the characteristics of the most important groups of visitors and development of special marketing programs and facilities adapted to their demands;
- Implementation of participatory approach in planning and implementation of the management activities with providing the necessary level of transparency;
- An iterative and step-by-step approach to the identification of problems, selection of the priorities and implementation of activities aimed at their solving.

Creation of adequate measures for protection should be based on visitors´ demands and appropriate support measures:

Governance model of the urban greenery and protected areas can be understood by analysing and applying the input-output model of political system [19]. Easton's model of the political systems seeks to explain complete political process as well as role of the main actors involved in that process. Environment can be understood as a complex of the economic and political realities of B-H´s society and natural factors that dynamically, continuously and interactively influence the political system. Visitors' demands are inputs to the system while supports are consisted out of all activities taken by responsible institution such as proclamation of protected area, establishment of the Cantonal public institution 'Spomenik prirode Vrelo Bosne', budget support etc. Political system should be understood as process where the KJU 'Spomenik prirode Vrelo Bosne' has central role. Based on support and demands from the environment, the manager of the responsible institution should make certain decisions and take action in order to meet visitors' demands. Results of this research, the visitors´ demands and their attitudes can be understood as information that indicates necessary directions in the creation of the outputs. What is more, this information clearly shows the weakness of the existing political system due to the visitors' dissatisfactions with the situation of the Vrelo Bosne. This place is not valuable for the citizens of Sarajevo only due to its natural, cultural, historical and landscape characteristics but also due to the fact that this is a unique natural complex of Sarajevo in terms of its suitability for sightseeing, recreation and overall relaxation. It can be concluded that creation of adequate measures for protection of this area based on visitors´ demands and supports presents one of the fundamental directions for managing the urban forest Vrelo Bosne.

Minimisation of possibility for the conflicts among different visitors´ segments/groups through the organization and spatial planning processes:

Research showed that there are two main groups of the visitors. The first group has low payment capacity and it is mainly consisted out of pupils, students and retired people. The reasons why they are going to Vrelo Bosne are mainly because of walking, recreation or just for spending some time in nature. Therefore, this group needs more recreational facilities and the infrastructure (i.e. trim paths, bicycle paths, walking paths etc.) and the park infrastructure (i.e. benches, playgrounds, canopies etc.). Older and retired people are interested in walking, relaxation in quiet environment while young people are interested for active recreation in nature. Therefore, the probability of having conflicting demands (i.e. needs for noise and silence, walking and cycling etc) over the same space between these two groups of the visitors is very high. That is the reason why, in the processes of management planning and organisation of Vrelo Bosne, minimisation of potentials for the conflicts should be seen as one of the most important actions.

Identification of the characteristics of the most important groups of visitors and development of special marketing programs and facilities adapted to their demands:

Opposite to the visitors with low payment capacity, there are visitors with relatively higher payment capacity. Their demands toward Vrelo Bosne are very diverse - from the different aspects of recreation to the sightseeing and catering facilities. However, the preconditions for meeting their demands are numerous, such as better tourist offer, professional tourist guides, developed informational and educational materials and facilities. It can be concluded that identification of visitors group, their characteristic and size and development of specific marketing programs which are adjusted to the demands of particular visitor group should be important direction for management of the urban forest Vrelo Bosne.

Implementation of participatory approach in planning and implementation of the management activities with providing the necessary level of transparency:

Comparing to the traditional government concept that includes top-down formulation of policy programs and instruments, governance concept supports an active role of various user/interest groups in the process of creation and implementation of the policy programs (Figure 2). Interactive relationship between the various interest/user groups (local community, visitors, different public institutions, political parties, trade organisations, tourism associations, land owners, NVO, public, research institutions etc.) in the model of creation and implementation of the management decision in the urban forest means not only cross-sectoral dialogue in the policy creation but also common responsibility in the implementation of agreed decisions. The fact that this is the model of continuous management decisions making in a terms of different (often conflicted) and changing demands cannot be ignored. This paper deals only with the visitors' demands which mean that creation of consistent management model would require information about the demands of other users and interest groups. Participatory approach in the creation and implementation of decision making in Vrelo Bosne, with assurance of certain level of transparency, is another fundamental direction for managing Vrelo Bosne.

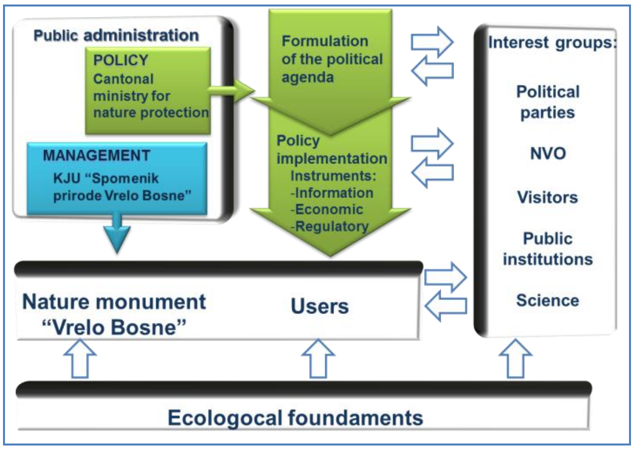


Figure 2: Model of creation and implementation of the management decision in Vrelo Bosne

An iterative and step-by-step approach to the identification of problems, selection of the priorities and implementation of activities aimed at their solving:

Generally, visitors are not completely satisfied with the management of Vrelo Bosne. This fact clearly indicates that some improvement has to be done. Phases of improvements can be presented by policy cycle and its phases of: identification, evaluation, selection, implementation and monitoring [20].

In the context of policy cycle, all visitors´ demands can be seen as integral part of the identification phase. Since all demands are not equally important and all interest groups do not have equal power they need to be analysed in the evaluation phase. Based on the previous analysis, the priority issues have to be selected, as well as needed activities. Taking into consideration all demands obtained in the research, priority should be given to the improvement of infrastructure in the broadest sense. Therefore, one of the necessary activities definitely should be the establishment of guard service which will increase safety of the place, especially during the evening hours. In the context of the political cycle, implementation of the proposed management directions, as well as other activities that need to be refined in the management plan, are parts of the next stage. Eventually, the success of the implementation of all activities is necessary to consider in the monitoring phase. In this context, monitoring is rather mean for ensuring continuous and iterative phases of the new political cycles, then the end of the process. Having in mind dynamic changes in society's demands towards natural resources, it is only theoretically possible that all activities are positively evaluated and that the political cycle is completed. In the context of continuity and repeatability of political cycle, it is necessary to ensure continuous monitoring of visitors´ demands that should help in the definition of directions for managing Vrelo Bosne.

3.2 Case study: Sedrenik School in Sarajevo

Elementary school 'Sedrenik' Sarajevo is located in north-east part of the city in high-density residential area. The school was constructed in 2011 by local authorities of municipality Stari Grad Sarajevo and Ministry for education of Sarajevo Canton. The School started with work in 2011/2012 school year. The idea that area around the school should be arranged as 'green classroom' was initiated by the school management in order to establish additional space for children where they would have possibility to learn more about the nature, different tree and plant species but also to have area that will ensure better quality of the teaching process.

Initial exploration work in the elementary school 'Sedrenik'

The results of the consultations between expert team and school management about the modes of creating environment around the school were an initial phases of designing functional schoolyard. Following the results of the observation and interview with manager and teachers, design-principles were set as follows:

- Functionality of space around the school;
- Safe and healthy environment;
- Commonly used plants and tree species in this area;
- Encouragement of creativity of children and their involvement in maintaining of 'green classroom'.

These principles have been confirmed by the pupils through their drawings.

Desing workshop in the elementary school 'Sedrenik'

The design workshop stage was organised in cooperation with experts and children from the first, second and third class.

Figure 3: Pupils´ drawings (I, II, III class)

We asked children to draw the desired look of the school surrounding and we asked them to act as the planners of their own schoolyard. The goal of this exercise was to find out the children's perspectives on issues such as how they perceive their school environment and surroundings etc. Pupils expressed their ideas through the drawings and indicated elements that they would like to have in their schoolyard (Figure 3). Drawings of the pupils from the first class had mainly included flowers and trees. Same also holds for the majority of drawings from the second class while only few of them included a playground. As it was expected, the third class was the most creative. Beside the flowers and trees, they draw a lot of fruit trees, playgrounds and surprisingly - fountains. Analysis of these drawings had resulted with the list of the desirable elements of schoolyard which was included in the site plan.

Prototyping in the elementary school 'Sedrenik'

Interviews with teachers, children drawings and respect of the abovementioned principles had helped in drawing a site plan for the schoolyard (Figure 4).

Figure 4: General site plan for the Sedrenik schoolyard

The Sedrenik schoolyard has been designed to intrigue, teach and excite children from a very young age about the importance of nature in the broadest sense. Pupils have been putted at the centre of the planning process, because schoolyard is the place where they spend the most of their time and where they need to feel comfortable. As it is previously mentioned some principles have been set up during the planning process.

Functionality of the 'green classroom':

According to the Vujković the space around the school should fulfil two main functions: educational and recreational. Fulfilment of these functions depends from available space and has to be in accordance with the needs of teaching process [21]. School gardens enable teachers to provide on-site environmental education which is preferred since some studies have shown that environmental education has positive effects on both student behaviour and academic performance. Students in environmental education programs tend to be more engaged and enthusiastic about learning. Also one of the benefits of the schoolyard is their positive effects on children` healthy and fitness as they spend more time active in the outdoors. Furthermore, children themselves in their drawings recognise needs for the playgrounds and for the named plants. For the recreation part, wooden playground and lawn for the running have been placed. However, focus was on the education. Wooden 'bear house' as a place where pupils would meet with the pictures of different native wild animal species has been planned. Beside animals, they would be able to see pictures of different native and introduced plants.

Safe and health environment:

Pupils have the right to play in the safe and stimulating environment. Design process has to predict that environment is suitable for children and that all plants are not dangerous for the health of the children. This means that plants are not detected as high toxic and that they are without thorns. By choosing these plants, the risks for health endanger has been minimised. However, some plants that are toxic (i.e. *Hedera helix*) and that has thorns (i.e. *Rosa* sp.) are planned, but they are placed in places which are inaccessible for children such as pergola and roof. For sure, children will not always be in the safe environment, thus they have to learn that some plants which they can meet daily can threaten their health.

Commonly used plants and tree species in this area:

Plants used for the school project were selected due to their diversity, nice colours or different and interesting forms. Two groups of commonly used plants have been chosen: introduced and indigenous species. Authors planned to mark each plant with the domestic and Latin name and with their origin. Decorative (mainly introduced) plants, which can be seen in the city, are very modestly represented and they serve to increase decoration of the place. These plants are mainly high decorative shrubs such as: *Acer palmatum, Clematis sp., Forsythia x intermedia, Juniperus horizontalis, Keria japonica, Lonicera x americana* etc. Indigenous plants from Bosnian house yards and gardens [22] are chosen because of their educative character so that children can meet with traditional plants that decorate the yards of their ancestors. It is known that Bosnian traditional gardens have a few indispensable parts such as: water, coloration, nice aroma, traditional cobble and boxwood [22]. Therefore, small fountain in the rock garden has been planned with the lot of Bosnian colourful and aromatic plants such as: *Begonia masoniana, Tagetes erecta, Sedum maximum, Thymus serpyllum, Mentha piperita* etc. It is planned that hedge should be composed from the boxwood (*Buxus sempervirens*). Beside these, one small orchard, which would bring joy to the pupil during the spring and autumn, has been planned. Orchard includes *Malus domestica*, *Prunus domestica*, *Prunus avium*, *Pyrus domestica*, *Rubus idaeus, Corylus avellana, Vitis Vinifera.*

Encouragement of creativity of children and their involvement in maintaining of 'green classroom':

Pupil's routes to school and recreation are also their routes to play. They know a little more of the physical environment in the school yard than adults, because they perceive it, see it and use it more intensively than others. Therefore, it is very important to leave some part of school yard disorganised, and give space to children to develop their creativity. FAO encourages schools to create learning gardens of moderate size, which can be easily managed by students, teachers and parents [23]. This space is situated in front so that children can use this space for planting some vegetables or other plants which can help them in the learning process. By preparing the soil, planting, nursing and maintaining of their favourite plants, pupils will develop responsibilities, they will feel the nature and love it. Moreover, it will help in the teaching process, where children would be able to see and touch all the things that they have learned about the nature and its processes.

3.3 Implementation of the case studies

After the research and the derivation of appropriate directions, fully respecting of the participatory design process would consider implementation of these results as the following step. However, neither of these two cases has been implemented. The case of the urban forest Vrelo Bosne is pure social research of urban greenery, thus it is not implemented yet. On the other hand, the case of the Sedrenik School was initiated by the management of the school. Therefore, this idea might be realized in the future. It is planned to include pupils in all stages of the creation of green classroom - from the planning process through the building and planting, to the never-ending maintenance of their own schoolyard and their continuous environmental education and cohesion.

4 CONCLUSIONS

Urban greenery issues are very modestly researched in the B-H. In particular, the political and sociological aspects of urban greenery are still poorly explored. This paper aims to present participatory, multidisciplinary and integrative approach in the planning and managing of the urban greenery that should serve to the better functionality of the urban green spaces. Participatory stages presented in the Figure 1, created by the authors, show that these phases can be applied to the different case studies with the different end-users populations. Therefore, the question such as: "Who represents end users in today's urban planning?" arises. Regardless their age, users have to be putted at the centre of the planning process. Since the schoolyards and/or urban forests are inseparable components of everyday life of end-users, their needs must be esteemed in urban planning in order to ensure functionality of urban green spaces and the social cohesion with them. Too often, the over-urbanized environment works against healthy human development in terms of the design and positioning of housing, parkland and transport systems. For sure, it is not well known how much the planning of urban green spaces that are taken now will affect human health in the future. However, it can bring only positive effect on their attitudes, behaviours, and preferences in the broadest sense. Experience and research have shown numerous benefits of school gardens and natural landscaping: students learn how to be focused and patient, how to ensure cooperation, teamwork and how to improve their social skills [25]. Therefore, to ensure all urban green spaces` functions, these areas need to be harmonized with the preferences of their final beneficiaries through adoptable planning and managing created in a way that should satisfy the needs and demands of their users.

5 ACKNOWLEDGMENTS

Sincerely thanks to all participants of the research in the urban forest Vrelo Bosne, who kindly answer on the questions and help in creating proposed policy directions. We also owed great thanks to the pupils of the Sedrenik School for drawing such nice and useful pictures of their desired schoolyard. Special acknowledgement we owed to the management of the Sedrenik School for their trust and for their all-out cooperation.

6 REFERENCES

[1] FAO 2009, International Meeting - Trees Connecting People: In Action Together, Meeting Proceedings, Bogotá, Colombia, 29 July to 1 August 2008.
[2] Konijnendijk C. C., 2008, The Forest and the City, The Cultural Landscape of Urban Woodland, Denmark.
[3] Ljuljić Mijatović T., Mrdović A. 1998, Prizvodnja cvijeća i ukrasnog bilja, Sarajevo.
[4] Janjić N. 2002, Šesti prilog poznavanja nesamonikle dendroflore Sarajeva i okoline, Radovi Šumarskog fakulteta Univerziteta u Sarajevu, Knjiga XXXII, br 1.
[5] Janjić N., 2007, Neka pitanja i problemi naše hortikulture, Naše šume, God. VI, br 10-11, UŠIT FBiH, Sarajevo.
[6] Treštić, T., Uscčuplić, M., Dautbašić, M., Kunovac, S., Ponjavić, M., 2003, Sistem praćenja štetočina i uzročnika bolesti na šumskom i urbanom zelenilu, Prvi simpozij poljoprivrede, veterinarstva i šumarstva, Neum, Zbornik radova 'Šumarstvo i hortikultura'.
[7] Dautbašić, M., Uscčuplić, M., Treštić, T., 2004, Zdravstvena slika stabala lipe u aleji 'Vilsonovo šetalište' u Sarajevu, Drugi simpozij poljoprivrede, veterinarstva, šumarstva i biotehnologije 'Strategija razvoja domaće proizvodnje', Bihać, Knjiga kratkih sažetaka.
[8] Dautbašić, M., Mujezinović O. 2008, Zdravstveno stanje zelenila na području Vogošće, Društvo za zaštitu bilja u BiH, 5. Simpozij o zaštiti bilja u BiH, Zbornik rezimea, Sarajevo.
[9] Beus, V., Mekić F. 2007, Kritički osvrt – šume i šumska zemljišta u Prostornom planu kantona Sarajevo, Naše šume, God VI, br. 8-9, UŠIT FBiH, Sarajevo.
[10] Hadžidervišagić, D. 2010, Valorizacija i tipizacija zelenih površina Sarajeva prema funkciji, značaju i položaju unutar fizičke strukture grada, Master rad, Šumarski fakultet Univerziteta u Beogradu.
[11] Lacan, I., McBride, J.R. 2009, War and trees: The destruction and replanting of the urban and peri-urban forest of Sarajevo, Bosnia and Herzegovina, Urban Forestry & Urban Greening br. 8.
[12] Avdibegović M., Vuletić D., Krilašević E., 2006, Karakteristike posjetitelja i razlozi posjeta šumskim područjima u kantonu Sarajevo, Radovi šumarskog instituta Jastebarsko vol. 41, br. 1-2., Jastebarsko.
[13] Fazlić, S., 2010, Utvrđivanje zahtjeva stanovništva prema šumi kao osnova za kreiranje smjernica šumarske politike u Kantonu Sarajevo, magistarski rad, Šumarski fakultet Univerziteta u Sarajevu.
[14] Brajić A., 2011, Utvrđivanje zahtjeva posjetilaca prema javnom gradskom zelenilu – studij slučaja 'Vrelo Bosne', završni rad, Šumarski fakultet Univerziteta u Sarajevu.
[15] Kurian, T. and Bandapudi, R., Participatory planning, available at http://www.sasanet.org/documents/Tools/Participatory%20Planning.pdf]
[16] Oltheten, T., 1999, Participatory Aproaches to planning for Community Forestry, A synthesis report, Forests, Trees and People Programme, Forestry Departement Working Papar No. 2.
[17] Spinuzzi, C., 2005, The methodology of participatory design, *Technical comunication.* Number 2, pp. 163-174.
[18] IUCN Protected Area Management Categories available at http://www.iucn.org
[19] Easton, D. 1965, A Systems Analysis of Political Life, Wiley, New York.
[20] Werner J., Wegrich K., 2003, Stage Models and Policy Processes: The Policy Cycle, in Textbook of Policy Analysis, Munich.
[21] Vujković, Lj., 2003, Pejzažna Arhitektura, planiranje i projektovanje, Šumarski fakultet, Beograd.
[22] Ljuljić Mijatović T., Švrakić A., 2006, Vrtna arhitektura bosanskih avlija kao dio kulturene baštine, Kantonlni zavod za zaštitu kulturno-historijskog i prirodnog naslijeđa Sarajevo.
[23] FAO 2005, Setting up and running a school garden, A manual for teachers, parents and communities, Rome.
[24] The value of the School Gardens available at http://www.greenhearted.org

Analysis and Evaluation of the Recycling System of Motor Vehicles at the End of the Life Cycle in Bosnia and Herzegovina

L. Dacić[1], S. Ormanović[2], S. Dacić[2]

[1]Faculty of Management and Business Economics, University of Travnik, Travnik, Bosnia and Herzegovina

[2]Faculty of Transport and Communications, University of Sarajevo, Sarajevo, Bosnia and Herzegovina

Abstract

Bosnia and Herzegovina is a country with an antiquated fleet, a country with a large number of vehicles at the end of the lifecycle. Existing management systems and disposal of ELV do not exist, nor the legal framework for dealing with this problem, but the treatment is performed on vehicles improperly and without any protective measures. Therefore, the aim and task of this paper is to define concepts that should ensure the sustainable development of the recycling of vehicles and the transport system in order to reduce waste and reduce vehicle pollution.

Keywords:
recycling, ELV, directive, law regulation, motor vehicles

1 INTRODUCTION

The public is informed that, vehicles have a wide impact on the ecological load on the environment. Today, there are around 500 millions of passenger vehicles in the world, and all forecasts for the coming century show that, there will be around 1,2 billion passenger vehicles if the new markets continue to spread in the present rate.

Vehicles must be produced, used and repaired in full compatibility with the lows of nature.

During the last few decades the motor industry pays great attention to define the ecological qualities of their products. Expectations that every product is ecologically acceptable, requires even in the first phase of research to rely on new materials**.** The crucial criteria in these processes are longevity and repeated entrance in the raw material cycle. During the construction every part and every circuit has to be visually marked in order to be easily identified. After the usage they have to be separated in order to easier enter the new usage. Appreciation of global aims S+3E (raw + energy + ecology + economy) is inspiration not only for new technologies in refining and additives production but also for continued optimization of technical, traffic, logistic and ecological qualities of vehicles and motors.

With the Directive on Waste of the EU and with the resolution on the politics of waste, it is requested from the member countries and future members of EU to, first of all, reduce waste production, recycle and build facilities with modern, sophisticated technologies. Besides, the member countries should also apply „The Polluter pays principle“, i.e. the polluter pays the costs of waste management.

2 ROLE AND SIGNIFICANCE OF RECYCLING MOTOR VEHICLES AT THE END OF THEIR LIFE CYCLE

Recycling is processing used materials (waste) into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution (from incineration) and water pollution.

Since 2008 in the European Union, the hierarchy of waste is spread into six components by *The Waste Framework Directive* (*Directive 2008/98/EC on waste*). Shifting from the 3R concept (reduce, reuse, recycle) to the 6R concept (reduce, remanufacture, reuse, recover, recycle, redesign) may result saving gains for both manufacturers and consumers. It is essential to integrate the 6R criteria into all phases of the vehicle development process. It is important to mention that the aim of this waste hierarchy is to extract the highest degree of practical benefit of products at the end of their life cycle and achieve waste minimization.

Recycling brings not only economical profit, but also reduces pollution. By using recyclates we save natural resources and energy. Recycling creates less air and water pollution unlike primary production of raw materials. Recycling saves spaces for disposal, creates new job opportunities in companies engaged in collecting, producing and distribution of secondary raw materials, saves money and protects plants and animals habitats.

Recycling contributes to reducing greenhouse gas emissions associated with the exploitation of mines and the production of materials. Besides, recycling and composting reduce greenhouse gas emission that would occur on depot during the release of methane CH4 and other greenhouse gases.

Recycling of used motor vehicles (EVL) in highly developed countries is very successful, especially after the 70ie years of the 20th century- after the introduction of shredder into the process of recycling used vehicles. Systems for recycling ELV have an amazing performance which is shown through two key indicators of recycling performance. The first indicator is the „recycling rate"which in developed countries exceeds 90% of the total number of used motor vehicles[1]. The second indicator is the „recyclability" which, today, exceeds 75 % in the recycling of vehicles, and mostly because of the process of recovery of metals of cars[2].

Products are said to have their lifetime, i.e. life cycle. In all life phases of a product it produces waste, and according to that it is practical to examine recycling through the life phases of a product. The life cycle of a product can be defined as a period of time from the development of the idea in order to satisfy the human needs to the eventual product removal from the social and natural environment. Based on the nature of process, the life cycle of a vehicle has four basic phases: *investigation and development, production, usage, recycling of used motor vehicles* (End of Life Vehicles, ELV). The last phase includes all processes which are connected to ELV, such as: takeover for the last owner, issue of a certificate for de-registration, dismantling, preparing materials for re-usage through different kinds of technological treatment, delivery of parts for re-installation, delivery of materials for producing new products and energy and shipment to the storage of useless waste.

An important stage of the recycling process is disassembly. Desai and Mital (2003) defined disassembly, in the engineering context, as organized process of taking apart a systematically assembled product (assembly of components).

Disassembly process may be clearly distinguished into two categories, based on the method of disassembly, non-destructive disassembly (dismantling) and destructive (shredding). Non-destructive disassembly can be divided into total disassembly and selective disassembly (Desai and Mital, 2003).

From end-of-life vehicles, dismantling companies first remove the oil, engine, transmission, tire, battery, catalytic converter, and other parts, which are commonly recycled or reused. Shredding companies then sort out the ferrous and non-ferrous metals and resin from the remaining vehicle bodies. While the ferrous and non-ferrous metals are recycled, the shredder residue is being disposed of as waste in landfills (Toyota Motor Company, 2005).

In order to most effectively utilize the earth's resources and reduce the volume of disposable waste, automobile recycling activities must include efforts to further reduce the volume of this waste and promote its reuse and recycling to ultimately achieve zero waste.

3 ANALYSIS AND EVALUATION OF THE RECYCLING SYSTEM OF MOTOR VEHICLES IN BOSNIA AND HERZEGOVINA AND SOLUTIONS FOR IMPROVEMENT

One of the main environmental problems in Bosnia and Herzegovina is the management of waste. The extent to which we effectively and fast solve the problem of waste management depends not only on the quality of the citizens' lives but also the appeal of B&H as a touristic destination, keeping its international perception of a country of preserved environment and healthy food production. The systematic, multiannual neglect and minimal investment in the management of ELV waste, created a very bad total image of the environment, and produced a large number of black points that are continuously filled with large amounts of vehicle's waste that directly endanger people's lives and health. The amount of ELV grows every day, and the infrastructure to control this waste does not exist.

The existing systems of managing and disposal of ELV does not exist at all, but there is a kind of „wild" purchase places where treatment is improper and without any protective measures. The information, that in 50% of cases of final disposal in this region happens on permanent storages that are „wild" disposals, where no processing is done, is devastating.

Figure 1: Curent ¨wild ¨ purchase places of ELV in Bosnia and Herzegovina.

For solving waste problems at the level of Bosnia and Herzegovina, there is a low on waste management on state level. In 2003 six outline laws have been passed at the Federation level. These outline laws are on environmental protection and they have been done in accordance to the requests of the European Union Legislative. Laws and subordinate regulations on waste management are as follow: **Law on environmental protection**, Official Gazette of the Federation of Bosnia and Herzegovina 33/03, **Law on waste management**, Official Gazette of the Federation of Bosnia and Herzegovina 33/03, **Law on collecting, producing and traffic of secondary raw and waste materials**, Official Gazette of the Federation of Bosnia and Herzegovina 35/98.

The existing legal regulations in B&H on recycling ELV are not sufficient for secure disposal of waste with less effect on the environment and people's health. Hence, waste management in the Federation of Bosnia and Herzegovina is regularized but only for other waste and this does not include the Law on recycling old motor vehicles. However, the introduction of additional legal regulations which are in force in most European countries would drastically improve the state in Bosnia and Herzegovina which would result in higher economical benefits and in reducing the adverse impact on environment in terms of pollution (air, water, soil).

Necessary for the waste problem solution in Bosnia and Herzegovina is the introduction of the EU Legal regulation on treatment of ELV. The relevant EU legal frameworks on this problem are:

- ELV Directive of the European Union (2000/53/EC),
- European Waste Catalog – EWC,
- Hazardous Waste List – HWL – with its amendments.

[1]This makes vechicle recycling significantly more effective in contrast to recycling other products or materials which are considered successful when they reach 50% of the recycling rate.

[2]Even this performanse level exceeds the recycling of a large nimber of other products or packaging materials.

By passing these directives, the number of wild purchase stations for secondary raw materials would be reduced and the clear and regular treatment of ELV and the associated materials would come to life.

Considering the number of companies that deal with the purchase of ELV vehicles and their recycling, it is evident that only the company C.I.B.O.S. branch fulfills the conditions defined by the ELV Directive of European Union. Only this company has the equipment for pressing or crashing vehicles. Other registered companies got the work permission although they do not fulfill the conditions defined by the ELV Directive of European Union.

Future operators have to be divided and situated on the entire territory of Bosnia and Herzegovina so citizens have the opportunity to leave their old cars in the nearest recycling center. The old cars will be safely and secure recycled and the last owners would get a compensation for it. The number of ELV would decrease and in accordance to that the environment pollution too.

Taking into consideration that only one authorized operator meets the requirements and their space division with the capacity to treat 10.000 vehicles per year. Since the assessment of the number of waste vehicles per year is 40.000, it is clear that if the model of integrated and sustainable recycling of ELV in Bosnia and Herzegovina is to be achieved, there are more equipped operators needed and thus more investments are needed.

Until adopting mentioned Directive, one way to reduce the number of wild purchase stations for secondary raw materials is building a network of centers for recycling and disassembling of vehicles in Bosnia and Herzegovina at the municipalities level. Economic justification of that process is shown in tables 1, 2 and 3.

Let us take a look at the investment expanses of business activities in the process of disassembling in companies dealing with disassembling with approximately 514 waste vehicles per year. [3]

	Estimated costs
Equipment for pressing (Used E-Z Crusher – Car Crusher), 1990 Model b portable, John Deere 4 cylinder diesel engine flattens entire auto in one process, in very good condition	**68.500,00 Euro**
Compact cleaning system, The Vehicle De-pollution Unit (VDU)	**6.400 Euro**
4 tanks /1000 liter	**2.000 Euro**
Forklift (Komastsu Reconditioned Forklift — Model# FG15-14)	**7.000 Euro**
Hazardous waste storage (30)	**10.500 Euro**
Scissor lift (surface mounter scissor lift)	**1.300 Euro**
Concreting and garden equipment (300 m2)	**30.000 Euro**
Equipment for office and spare parts storage (40 m2)	**14.000 Euro**
Equipment for the cleaning room (120 m2)	**42.000 Euro**
TOTAL:	**181.700 Euro**

Table 1: Expanses of the municipal company for disassembling with approximately 514 waste vehicles per year.

The following table shows the costs and revenues for the municipal company for disassembling.

	Annual costs of disassembling in Euro
Salaries for employees (4 employees), two employees for cleaning and the work on the forklift, one worker on the pressing machine and one engineer for managing technical systems	**28.800,00 Euro**
Electricity costs	**2.400,00 Euro**
Water costs	**1.560,00 Euro**
Tools and material costs (greases, fuel)	**8.400,00 Euro**
Amortization	**4.200 Euro**
Maintenance	**840 Euro**
TOTAL:	**46.200 Euro**

Table 2: Approximation of the total annual motor vehicle recycling costs on the territory of a municipality.

The total annual income of a disassembling company in a municipality we get out of the total annual revenue minus total annual costs.

Ar = Tr – Tc = (159, 24 x 514) – 46.200 Euro = 81.849,36 Euro - 46.200 Euro = 35.649,36 Euro

The average payback period of the investment in a disassembling company with a pressing machine and without shredding in a municipality is (181.700 Euro/35.649, 36 Euro) more than five years.

[3] Data are result of the research made by author.

4 SUMMARY

In order to improve the recycling system it is necessary to build a network of centers for recycling and disassembling of vehicles in Bosnia and Herzegovina. In the Republic of Bosnia and Herzegovina there are 137 self-governments which include municipalities and cities.

If in each municipality be invested 181.700 Euro per disassembling company, then the total investment would be approximately 24 million Euros and if from the needed investment for the municipality disassembling company the shredding operators were deducted, the total investment for disassembling would be even less.

Regarding that the necessary disassembling investments are less, and that in the revenues of the municipal disassembling companies, the revenues of the used spare parts sale are not counted because of the simplicity of the bill, which shortens the payback period of five years, we come to the conclusion that establishing an integral and sustainable recycling model for waste vehicles in Bosnia and Herzegovina it is necessary to start from the program assistance for the development of municipal disassembling companies.

By achieving this, real conditions for a high life quality of future generations would be created through conservation of natural resources and enhancement of environment on regional and global level.

4 REFERENCES

[1] Andersen, F., Larsen, H., 2008, Projection of end-of-life vehicles**,** International Journal Of Automotive Technology And Management**,** Issue: February.

[2] Bellmann, K., Khare, A., 2000, Economic issues in recycling end-of-life vehicles*,* Technovation, Volume: 20, Issue: November 1999, Pages: 677-690.

[3] Zameri, M., Saman, M., 2006, End of life vehicles recovery: process description, it's impact and direction of research**,** Jurnal Mekanikal, Vol.21, 40-52.

[4] Kanari, N., Pineau, J.L., Shallari, S., 2003*,* End-of-life vehicle recycling in the European union**,** Jom , Volume: 55, Issue: 8, Publisher: Springer Boston, Pages: 15-19.

[5] Desai, A., Mital, A. 2003, Evaluation of Disassemblability to Enable Design for Disassembly in Mass Production, International Journal of Industrial Ergonomics, Vol. 16(7), 712-732.

[6] Zameri, M., Afrinaldi, F., Zakuan,N., Blount, G., Goodyer, J., Jones R., Jawaid, A., 2010, Strategic Guidance Model for Product Development in Relation with Recycling Aspects for Automotive Products, Faculty of Mechanical Engineering, Universiti Teknologi Malaysia. Journal of Sustainable Development, Malaysia.

[7] Jeong, K.M., Hong, S.J. Lee,J.Y., Hur, T., 2007, Life Cycle Assessment on End-of-Life Vehicle Treatment System in Korea, Journal of Industrial Engineering and Chemistry., Vol. 13, No. 4, 624-630.

	Weight per vehicle		Recyclability		Selling price €/ton	**Revenue in €**
	%	Ton	%	Ton		
Metals	68	0,68	90	0,612	150	**91,8**
Non-ferrous metals	6	0,06	90	0,054	1100	**59,4**
Plastics	8	0,08	100	0,08	63	**5,04**
Fuel	0,2	0,002	100	0,002	1000	**2**
Engine oil	0,4	0,004	90	0,002	500	**1**
TOTAL						**159,24**

Table 3: Estimated total revenue obtained from the raw materials per vehicle on the territory of a municipality.

Comparison of Dynamic Characteristics of Electric and Conventional Road Vehicles

S. Beganović[1], S. Dacić[1]
[1]Faculty of Traffic and Communications, University of Sarajevo, Bosnia and Herzegovina

Abstract
Power-speed and torque-speed profiles of electric motor and internal combustion engine (ICE) differ significantly, thus dictating different dynamic characteristics of electric and conventional vehicles. The comparative analysis of dynamic characteristics of series production electric and conventional vehicles is performed using mathematical method and available data. The rule of 'comparing apples to apples' is followed. Resulted diagrams and following conclusions mostly indicate that electric motor utilization for vehicle propulsion has advantages over ICE utilization and that electric vehicles can compete with conventional ones. Disadvantages of electric vehicles compared to those of conventional vehicles are negligible, especially in city driving conditions.

Keywords:
Conventional Vehicle, Comparison, Dynamic Characteristics, Electric Vehicle

1 INTRODUCTION

Compared to conventional road vehicles[1] it is proved that electric road vehicles[2] represent significantly more acceptable solution from the standpoint of the environmental impact. Thereby, electric vehicles (EVs) also have negative impact on the environment whose intensity depends on the way of producing the electricity used to propel them. Consequently, the most attractive way is the use of renewable sources to generate the electricity which minimizes the negative environmental impact of electric vehicles and emphasizes their advantages over conventional ones [1]. One of the major drawbacks of electric vehicles is their relatively small driving range but there are efforts being made to find and apply advanced technical and technological solutions in order to alleviate it. This drawback is not so important if vehicle's exploitation is characterised mostly by driving inside cities.

In addition to environmental advantages of EVs it is also worthy to notice the advantages from the aspect of dynamic characteristics of EVs[3]. These advantages are the consequence of torque-speed and power-speed characteristics of an electric motor which are close to the ideal performance characteristics for a road vehicle traction power plant [2]. In accordance with this similitude, it is enough to use transmission with just one or two gears in EV propulsion system to realise vehicle performance requirements [2]. Electric propulsion system with this kind of transmission positively affects conditions and comfort of driving because it is not necessary to install a complicated gearbox or a clutch [3]. This characteristic of electric propulsion is emphasized in city driving conditions, especially in those cities with large number of roads with significant sections on the rise.

Traffic congestions represent remarkable cost which is primarily generated during the urban peak traffic periods and it has a character of external cost for individuals which means it is economically inefficient [4]. Among other things the quality of living in cities significantly depends on characteristics of traffic flows because city transport system is correlated to social activities. Adopting road vehicles with electric propulsion would reduce traffic congestions in cities. This specifically refers to heavy vehicles used for the carriage of passengers and those used for carriage of goods whose dynamic characteristics would improve (the acceleration performance and the ability to overmaster a road rises) by applying the electric propulsion and thus lead to the improvement of traffic flow characteristics reflected by the equivalent of reducing the number of vehicles on the roads [5]. In addition to this, adopting larger number of cars and commercial vehicles with electric propulsion would initiate the synergy effect of significantly reducing traffic congestions. This effect would reach its maximum if electric vehicles would replace all conventional vehicles in cities[4].

To organize a quality transport system of a city it is required to conduct planning within the systemic approach [6]. Thus having the knowledge of characteristics of transport system equipment is necessary, among other things, in order to maximize the function of a city transport system. In this regard occurs the necessity of having the knowledge of different kinds of road vehicle propulsion system because vehicles are basic entities of a transport

[1] A conventional road vehicle (or conventional vehicle) is a road vehicle propelled exclusively by an internal combustion engine (ICE) which uses only diesel or petrol fuel to generate the propulsion energy.
[2] An electric road vehicle (or electric vehicle (EV)) is a road vehicle propelled exclusively by an electric motor. Types of EVs are: battery electric vehicles (BEVs) and fuel-cell EVs (FCVs). BEVs use electricity stored in rechargeable battery packs charged by using an off-board electricity source. FCVs use hydrogen gas stored in its tank inside the vehicle and oxygen to generate the electricity by their chemical reaction in on-board fuel-cells.
[3] The electric motor utilization for propulsion of road vehicles is specifically interesting from the aspect of some characteristic road goods transport and public transport in cities.
[4] Similar effects would be initiated by utilizing the hybrid propulsion of road vehicles (hybrid electric or hybrid hydraulic propulsion).

system together with its infrastructure. This becomes more important factor of transport planning from the standpoint of transport policy which aims to improve the mobility with regard to minimizing the negative environmental impacts.

Majority of research projects on electric vehicles are usually focused only on environmental impact of EVs and their economic characteristics while minority concerns detailed interpretation of their dynamic characteristics and comparisons to those of conventional vehicles. Thus this research is focused on comparative analysis of dynamic characteristics of conventional vehicles and those of an EV with aim to perceive their advantages and disadvantages. To carry out this comparative analysis the case study of series production vehicles is used and the 'rule of comparing apples to apples' is followed in selection of vehicles for this research. Dynamic characteristics (dynamics) of a road vehicle are part of its basic exploitation characteristics and they depend on its tractive and breaking characteristics. This research concerns dynamic characteristics from the aspect of tractive characteristics of a road vehicle.

2 TECHNICAL DATA AND METHODOLOGY

2.1 Technical data

The selected vehicles, for which the evaluation and the comparative analysis of their dynamic characteristics is conducted, are following series production vehicles:

- Renault Fluence 1.6 16V 110 (the conventional vehicle with internal combustion engine which uses petrol fuel (petrol ICE)),
- Renault Fluence dCi 105 (the conventional vehicle with internal combustion engine which uses diesel fuel (diesel ICE)),
- Renault Fluence Z.E. (battery electric vehicle (BEV)).

There were two reasons for this selection. The first reason is public availability of the technical data required to conduct the evaluation and the second one is that these vehicles are produced by the same vehicle manufacturing company and represent the variants of the same vehicle model.[5]

Basic technical data of the selected conventional vehicles [7] and the calculated or adopted values required to conduct the evaluation of dynamic characteristics of conventional vehicles are given in Tables 1 and 2. Basic technical data of the electric vehicle [8] [9] and the calculated[6] or adopted data required to conduct the evaluation of dynamic characteristics of the electric vehicle are given in Tables 3 and 4.

Performance characteristics of internal combustion engines which propel the conventional vehicles are given in Figure 1. These characteristics were formed by reading the diagrams of performance characteristics of diesel and petrol engines published by the manufacturer of the vehicles [7].

Using technical data of the EV (Renault Fluence Z.E.) conceptual model of the EV [9] and technical data of the series production EV [8] published by its the manufacturer the performance characteristics of the EV were drawn as given in Figure 2.

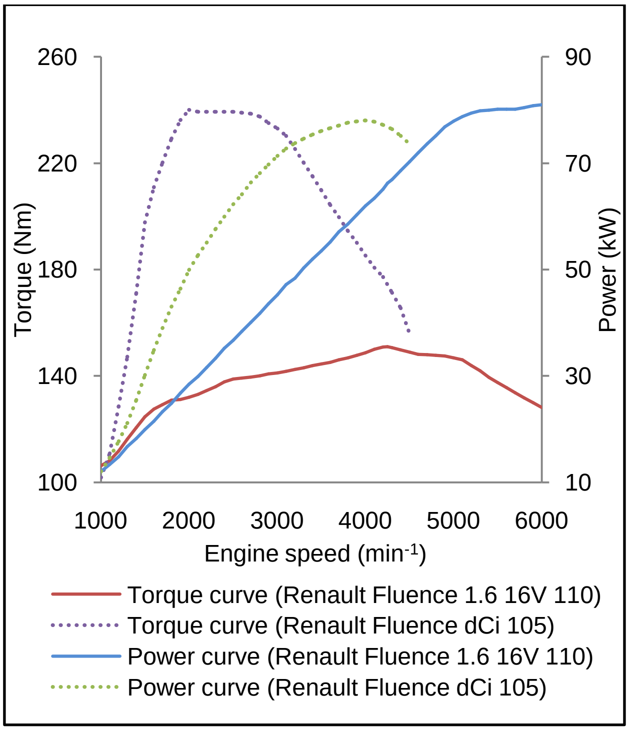


Figure 1: Performance characteristics of the petrol ICE which propels Renault Fluence 1.6 16V 110 and performance characteristics of the diesel ICE that propels Renault Fluence dCi 105.

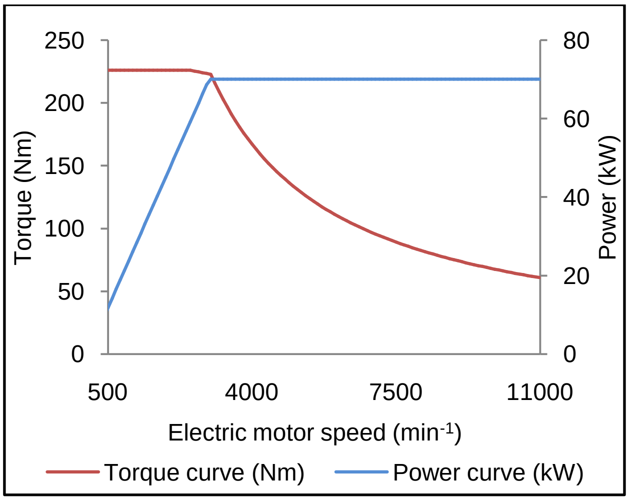


Figure 2: Performance characteristics of electric motor which propels Renault Fluence Z.E.

[5] Hereinafter the term 'the vehicle with petrol ICE' denotes Reanult Fluence 1.6 16V 110, the term 'the vehicle with diesel ICE' denotes Renault Fluence dCi 105 and the term 'the conventional vehicles' denotes both of them. The term 'the electric vehicle (EV)' denotes Renault Fluence Z.E.

[6] Some of data given in tables 1, 2, 3 and 4 were not published by the manufacturer of the vehicles. Thus they were calculated by using other published data.

Vehicle characteristics	Renault Fluence 1.6 16V 110	Renault Fluence dCi 105	Vehicle characteristics	Renault Fluence 1.6 16V 110	Renault Fluence dCi 105
Fuel type	Petrol	Diesel	Transmission ratio in the 1st gear i_1 (-)	3,619	4,887
Cubic capacity of the engine (cm^3)	1598	1461	Transmission ratio in the 2nd gear i_2 (-)	1,989	2,551
Maximum power (kW)	81 at 6000 min^{-1}	78 at 4000 min^{-1}	Transmission ratio in the 3rd gear i_3 (-)	1,353	1,733
Maximum torque (Nm)	151 at 4250 min^{-1}	240 at 2000 min^{-1}	Transmission ratio in the 4th gear i_4 (-)	1	1,278
Gearbox characteristics	5-gear manual	6-gear manual	Transmission ratio in the 5th gear i_5 (-)	0,797	1
Drive configuration	Front-wheel drive	Front-wheel drive	Transmission ratio in the 6th gear i_6 (-)	-	0,836
Mass of unladen vehicle (kg)	1225	1277	Transmission ratio of the final drive i_0 (-)	4,421	3,059
Mass of vehicle with driver and basic luggage (kg)	1310	1362	Product of a shape resistance coefficient and a frontal surface of vehicle c_xA (m^2)	0,72	0,72
Payload (kg)	500	500	Number of passenger seats	5	5

Table 1: Basic technical data of two vehicles: Renault Fluence 1.6 16V 110 and Renault Fluence dCi 105.

Calculated or adopted values	Renault Fluence 1.6 16V 110	Renault Fluence dCi 105	Calculated or adopted values	Renault Fluence 1.6 16V 110	Renault Fluence dCi 105
Transmission efficiency coefficient in the 1st gear η_1 (-)	0,95	0,95	The rotating masses influence coefficient in the 1st gear λ_1 (-)	1,5099	1,696
Transmission efficiency coefficient in the 2nd gear η_2 (-)	0,96	0,96	The rotating masses influence coefficient in the 2nd gear λ_2 (-)	1,2669	1,277
Transmission efficiency coefficient in the 3rd gear η_3 (-)	0,97	0,96	The rotating masses influence coefficient in the 3rd gear λ_3 (-)	1,1259	1,245
Transmission efficiency coefficient in the 4th gear η_4 (-)	0,98	0,97	The rotating masses influence coefficient in the 4th gear λ_4 (-)	1,058	1,078
Transmission efficiency coefficient in the 5th gear η_5 (-)	0,98	0,98	The rotating masses influence coefficient in the 5th gear λ_5 (-)	1,056	1,063
Transmission efficiency coefficient in the 6th gear η_6 (-)	-	0,97	The rotating masses influence coefficient in the 6th gear λ_6 (-)	-	1,056
Efficiency coefficient of the final drive η_0 (-)	0,97	0,96	Dynamic radius of a wheel r_d (m)	0,32	0,32
			Air density ρ (kg/m^3)	1,25	1,25

Table 2: Calculated and adopted values used to conduct the evaluation of dynamic characteristics of Renault Fluence 1.6 16V 110 and Renault Fluence dCi 105.

Electric motor type	Synchronous AC motor	Mass of unladen vehicle (kg)	1543
Electric motor maximum power (kW)	70 at 3000-11000 min^{-1}	Maximal allowable vehicle mass (kg)	1961
Electric motor maximum torque (Nm)	226 at 400-2500 min^{-1}	Mass of vehicle with driver and basic luggage (kg)	1628
Traction battery (technology / weight)	Lithium-ion / 280 kg	Transmission ratio in the 1st gear i_1 (-)	1
Transmission type	Direct drive (single gear) with reducer and forward/reverse inverter	Transmission ratio of the final drive i_0 (-)	9,83
Drive configuration	Front-wheel drive	Driving range - NEDC combined cycle (km)	160
		Number of passenger seats	5

Table 3: Basic technical data of Renault Fluence Z.E. (battery electric vehicle).

Overall transmission efficiency coefficient η_T *(-)*	0,901
The rotating masses influence coefficient in the 1st gear λ_1 *(-)*	1,059
Dynamic radius of a wheel r_d (m)	0,32
Air density ρ (kg/m^3)	1,25
Product of a shape resistance coefficient and a frontal surface of vehicle c_xA *(m^2)*	0,72

Table 4: Calculated and adopted values used to conduct the evaluation of dynamic characteristics of Renault Fluence Z.E.

2.2 Methodology of conducting the evaluation of vehicle dynamic characteristics

The expression made by Wallentovitz is used to determine the rolling resistance coefficient [10]:

$$f = f_0 + f_1 v + f_2 v^4 \qquad (1)$$

where the parameters v stands for vehicle speed expressed in m/s. For radial tyres which could be used for reaching vehicle high speeds, the values of the coefficients f_0, f_1 and f_2 are:

$$f_0 = 9{,}91 \cdot 10^{-3} \qquad (2)$$

$$f_1 = 1{,}95 \cdot 10^{-5} \qquad (3)$$

$$f_2 = 1{,}76 \cdot 10^{-9} \qquad (4)$$

The values of driving force on a wheel in a particular gear are determined by following expression [10]:

$$F_{O,mj} = \frac{M_e(n)\ i_{mj}\ i_0\ \eta_{mj}\ \eta_0}{r_d} \qquad (5)$$

where the parameters in the expression (5) are: $M_e(n)$ - torque of the power plant in function of its speed expressed in revolutions per minute (rpm), η_{mj} - transmission efficiency coefficient in a particular gear, η_0 - efficiency coefficient of the final drive, and r_d - dynamic radius of a wheel.

Dynamic factor is a value which represents the modification of a driving force and is used for qualitative rating of vehicles and the following expression is used to determine it [10]:

$$D_{mj} = \frac{F_{O,mj} - R_v}{mg} \qquad (6)$$

where the parameters in the expression (6) are: D_{mj} - dynamic factor in a particular gear, R_v - air resistance, m - vehicle mass.[7]

Values of dynamic factor should be combined with the values of overall resistance to vehicles motion in order to analyse their dynamic characteristics. Air resistance is calculated in dynamic factor and thus the overall resistance to vehicles motion is expressed by coefficient of road resistance (rolling resistance plus grade resistance divided by weight of a vehicle) [10]:

$$\psi = f\cos\alpha + \sin\alpha \qquad (7)$$

where α stands for a degree of a road rise.

Acceleration of a vehicle in a particular gear is determined by the following expression [10]:

$$j_{mj} = \frac{g}{\lambda_{mj}}(D_{mj} - f\cos\alpha - \sin\alpha) \qquad (8)$$

where the parameter λ_{mj} stands for the coefficient of rotating masses influence in a particular gear.

Dynamic performances of a vehicle - time (t) and distance (s) of accelerating a vehicle till it reaches a specified speed - are determined using the numerical procedure with following expressions [10]:

$$t = \sum_{i=0}^{i=n} \frac{v_{i+1} - v_i}{\frac{j_{i+1} + j_i}{2}} \qquad (9).$$

$$s = \sum_{i=0}^{i=n} \frac{(v_{i+1} - v_i)\cdot(t_{i+1} - t_i)}{2} \qquad (10).$$

3 ANALYSIS OF DYNAMIC CHARACTERISTICS

In order to determine the acceleration of the observed vehicles as well as time and distance required to accelerate them to a specified speed on a horizontal road, using data and expressions of the second chapter, the diagrams of required and available force on the wheel were constructed as well as those of dynamic factor with assigned coefficient of road resistance which are shown in Figures 3, 4 and 5. Thus on the basis of these diagrams (Figures 3, 4 and 5), diagrams of acceleration,

[7] Mass of a vehicle with driver and basic luggage (mass of unladen vehicle plus 85 kg) is used in the evaluation (see tables 1 and 3).

acceleration time and acceleration distance of observed vehicles are given.

Before analyzing the results and presenting the conclusions it should be noted that the evaluation of dynamic characteristics of the conventional vehicles was conducted with the premise that the initial driving speed in a certain gear is equal to the maximum speed attained in a previous gear (there is no loss of speed when shifting the gears while accelerating the vehicle). This premise additionally improves acceleration performance of the conventional vehicles because the loss of speed occurs in real driving conditions and it is caused by the presence of resistances to vehicle motion which are particularly expressed when driving at higher speeds. This should be kept in mind when interpreting the evaluation and analysis results. Also, in this sense, it should be considered that the EV has a greater mass without payload in comparison with the conventional vehicles and also lower maximum power of power plant (the mass of the vehicle with the petrol ICE is 318 kg lower and the mass of the vehicle with the diesel ICE is 266 kg also lower).

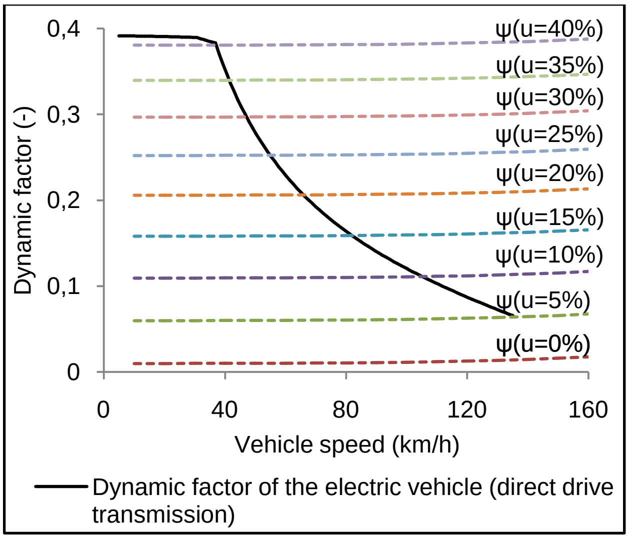


Figure 3: Dynamic factor diagram of the EV with overall resistance to its motion.

By analyzing the diagrams shown in Figures 3 and 4 it can be concluded that the electric vehicle has advantages over a vehicle with the diesel ICE when it comes to starting the vehicle from standing on the upward grades above 34%.[8] At these grades the EV has a better efficiency of propulsion than the vehicle with the diesel ICE. Generally, a vehicle with the diesel ICE has the ability to attain and maintain higher motion speed at road upgrades from 0-40% (or more).

Comparing the EV and the vehicle with the petrol ICE (Figure 3 and Figure 5) in terms of ability to overcome the road upward grades, it can be concluded that both vehicles have the ability to start from standing at the maximum grade value (40%) taken into consideration of this research. From the aspect of attaining and maintaining higher speeds at the upward grades between 29% and 31% the EV has the advantage over the vehicle with the petrol ICE. For other grade values the vehicle with the petrol ICE reaches higher speeds. In order to reach and maintain the maximum attainable driving speed of the vehicle with the petrol ICE at upward grades with values between 29% and 40% it is necessary for its engine to reach very close to the maximum number of revolutions per minute. The EV, by contrast, reaches and maintains its maximum attainable speeds on grades between 29-40% at which the electric motor runs in the first third of the maximum value of revolutions per minute. This fact shows the advantage of the electric propulsion from the aspect of power plant efficiency (energy consumption and loading characteristics) in this exploitation conditions which implies certain economic benefits of electric motor utilization for propulsion of road vehicles.

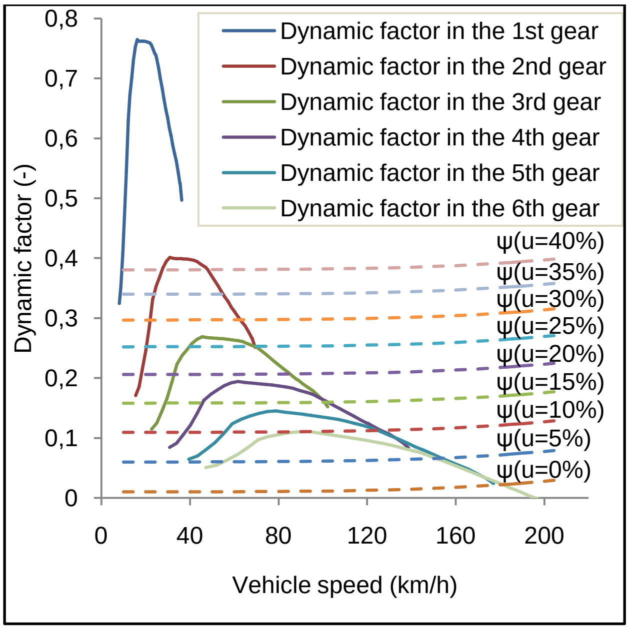


Figure 4: Dynamic factor diagram of the vehicle with diesel ICE with overall resistance to its motion.

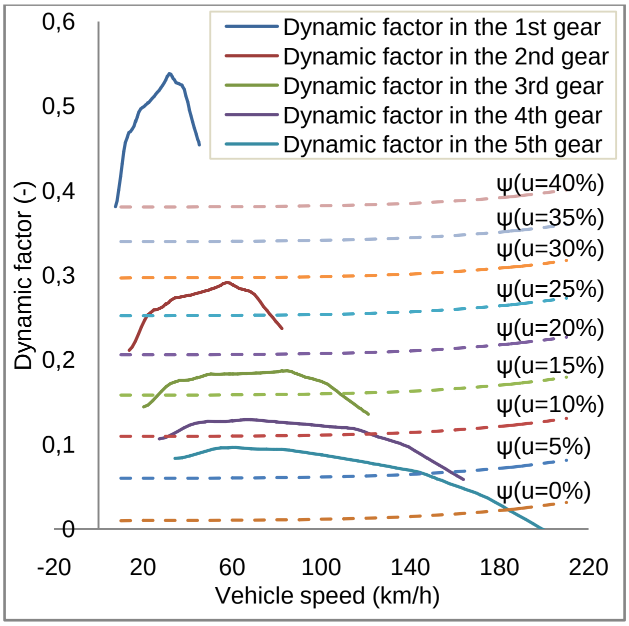


Figure 5: Dynamic factor diagram of the vehicle with petrol ICE with overall resistance to its motion.

From the standpoint of ease and comfort of driving, the electric vehicle has advantage over the conventional vehicles because of the simplicity of transmission and fast response to acceleration request of a driver. This is significant in all conditions of exploitation and particularly when starting the vehicle from standing on the road with a higher upward grade which is the case in some city roads.

[8] The ability to master upward grades of a road denotes the ability of starting a vehicle from standing, primarily, and the ability to attain and maintain a specified driving speed at a particular grade, secondary.

Figures 6 and 7 show the comparison diagrams of the EV acceleration and acceleration of the conventional vehicles.

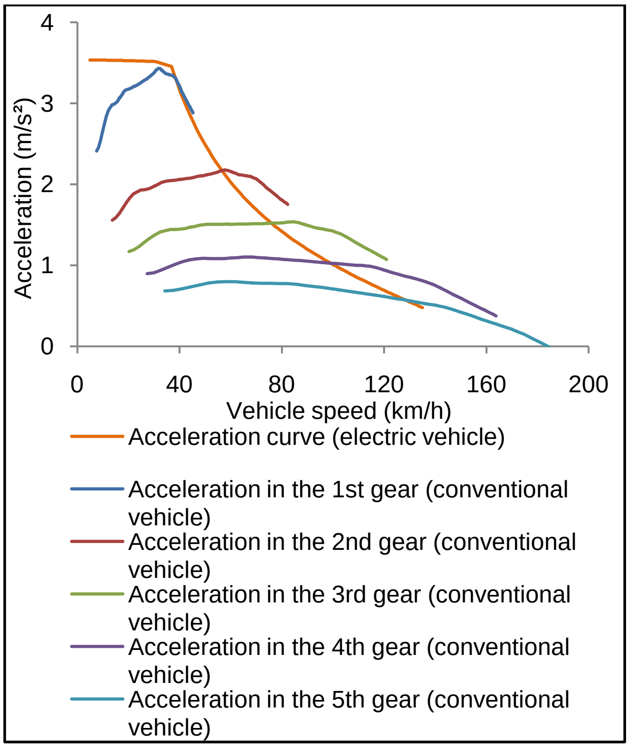


Figure 6: Diagram of compared acceleration curves of the EV and the vehicle with petrol ICE.

Figure 6 shows that the EV attains higher values of acceleration until it reaches a speed of 38.5 km/h in comparison with the vehicle with petrol ICE. After reaching that speed the vehicle with the petrol ICE achieves higher values of acceleration until it reaches its maximum speed of motion in the first gear (45.24 km/h). After shifting from the first to the second gear a decline in its acceleration happens by which the EV attains higher acceleration until reaching a speed of 56.3 km/h. After attaining this speed the vehicle with the petrol ICE again attains higher acceleration values and retains them until it reaches the maximum speed on the horizontal road. The advantage of attaining better acceleration performance fr.5om starting from standing state to reaching a speed of 36 km/h is an important feature in many conditions of exploitation, such is, for example, city driving, which becomes multiplied benefit if we add the previously explained characteristics of electric propulsion. Concerning that there are benefits from acceleration when moving in a speed range from zero to 38.5 km / h and from 45.25 to 56.3 km/h it can be concluded that the electric vehicle provides significant advantages in specific exploitation conditions such as driving in a city traffic.

When compared to the vehicle propelled by the diesel ICE (Figure 7), it is concluded that the EV achieves greater values of acceleration from starting the vehicle from standing to reaching a speed of 12.27 km/h, and also in the speed range of 30.7 km/h to 42.95 km/h. In actualization of other speed values, vehicles with the diesel ICE attain higher acceleration values. The reason for this advantage of the vehicle with the diesel ICE is, among other things, the greater value of maximum its engine torque. However, previously presented acceleration advantage of the EV is significant from the aspect of city traffic where faster starting the vehicle from standing and overtaking at certain speeds is important.

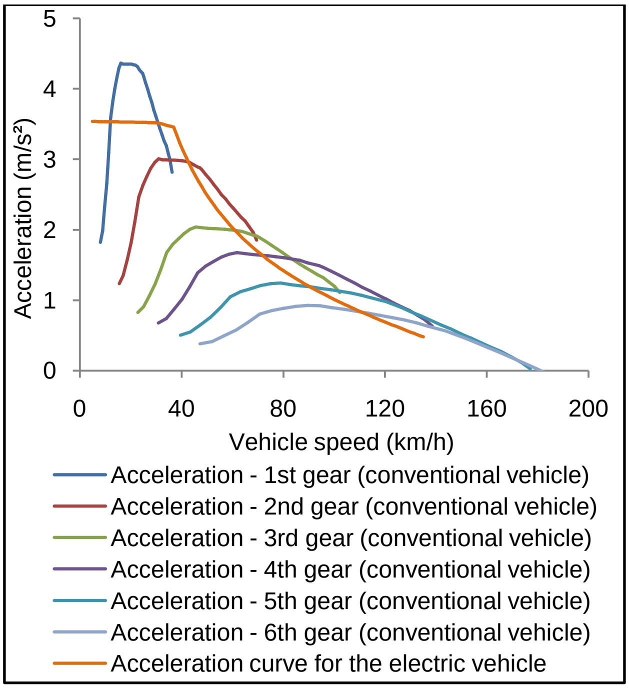


Figure 7: Diagram of compared acceleration curves of the EV and the vehicle with diesel ICE.

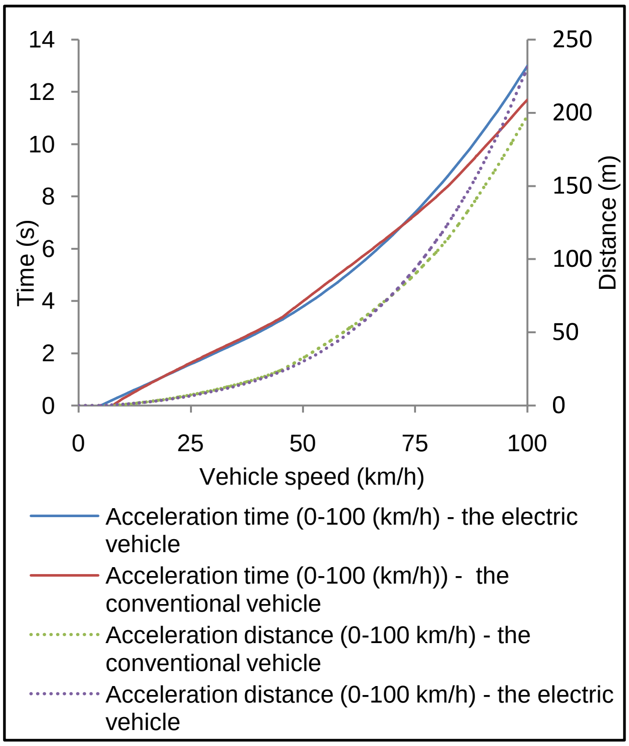


Figure 8: Diagram of time and distance required to accelerate the EV and the vehicle with the petrol ICE from 0-100 km/h.

Finally, Figures 8 and 9 show the comparison diagrams of time and distance required to accelerate vehicles from standing start to a speed of 100 km/h. The EV takes less time to attain a speed of 70 km/h in relation to the vehicle with the petrol ICE. In comparison with the vehicle propelled by the diesel engine it is shown that the EV takes slightly more time to accelerate. Keeping the premise explained at the beginning of this chapter in mind it can be concluded that these relations between the EV and the conventional vehicles would be slightly different in the sense of acceleration time advantages of the EV without that premise and if the conditions observed in the evaluation of dynamic characteristics were close or equal to those of real driving performance.

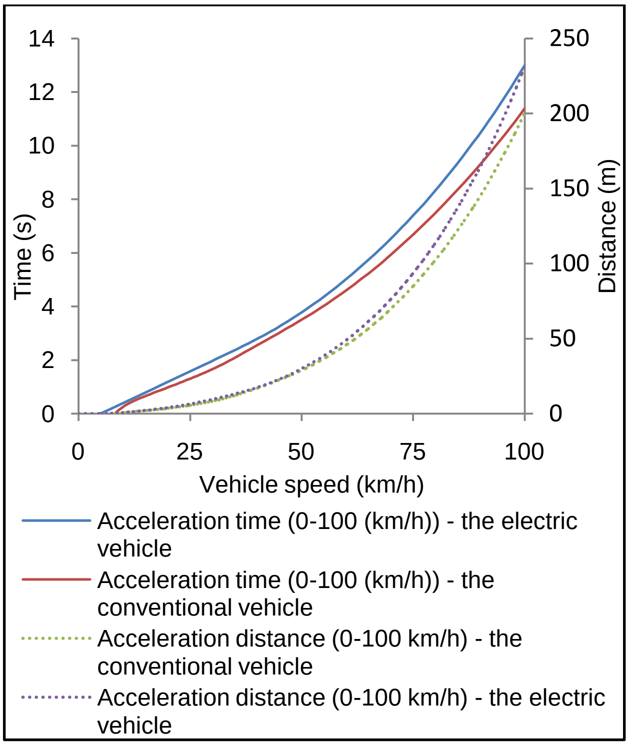


Figure 9: Diagram of time and distance required to accelerate the EV and the vehicle with the diesel ICE from 0-100 km/h.

4 CONCLUSION

Based on the dynamic characteristics comparison of the electric vehicle and the conventional vehicles it can be said that the vehicles propelled by an electric motor are mostly equal with their corresponding conventional vehicles. Under certain conditions of the exploitation, electric vehicles have significant advantages (driving in city traffic and mastering certain upward grades of a road). Disadvantages of electric vehicles are mainly manifested in achieving higher driving speed than those which are common to city traffic conditions. Advantages of electric vehicles could be significantly improved by reducing the weight of the vehicle battery which would greatly alleviate their disadvantages or completely eliminate them.

5 REFERENCES

[1] Granovskii, M., Dincer, I, Rosen, M.A., 2006; Economic and environmental comparison of conventional, hybrid, electric and hydrogen fuel cell vehicles; Journal of Power Sources, Volume 159, 1186–1193

[2] Ehsani M., Gao Y., Emadi A.; Modern Electric, Hybrid Electric and Fuel Cell Vehicles - Fundamentals, Theory, and Design - Second Edition; Taylor and Francis Group, LLC, Boca Raton, 2010

[3] Joeri Van Mierlo; Simulation Software for Comparison and Design of Electric, Hybrid Electric and Internal Combustion Vehicles with Respect to Energy, Emissions and Performances; Brussels, 2000. Available at: http://etecmc10.vub.ac.be/publications/DPRjvm.pdf

[4] Victoria Transport Policy Institute; Transportation Cost and Benefit Analysis: Techniques, Estimates and Implications [online guidebook for quantifying the full costs and benefits of different transportation modes], Chapter 5.5 Congestion. Available at: http://www.vtpi.org/tca/tca0505.pdf

[5] Smith, D., 2006; Hybrid Propulsion Systems for Port Drayage; National Urban Freight Conference 2006, [online] Long Beach: The Westin Long Beach, February 2. Available at: http://www.metrans.org/nuf/documents/DSmith.pdf

[6] Reis, B.; Tozi, L.; Brito Jr, I.; Sousa, V., 2010; A method to improve urban mobility and reduce emissions of carbon; 12th World Conference on Transport Research, Lisbon, July 13. Available at: intranet.imet.gr/portals/0/usefuldocuments/documents/02069.pdf

[7] Renault Cyprus, Technical Specifications of Renault Fluence 1.6 16V 110 and Renault Fluence dCi 105, http://www.renault.com.cy/files/technicals/technical_fluence.pdf

[8] Renault Media, Renault Fluence Z.E. Technical Specifications, http://www.media-renault.eu/fluence-ze/files/108_fr_tech.pdf

[9] International press website of Renault Group; Renault Fluence Z.E. and Kangoo Express Z.E.: finalized designs revealed and pre-reservations open. Available at: http://media.renault.com/global/en-gb/renault/Media/RelatedDocuments.aspx?mediaid=10997

[10] Pikula, B.,Trobradović, M., Dacić, S., 2008; Osnove dinamike vozila; University of Sarajevo, Sarajevo

Justification of Electric and Hybrid Vehicle Use in Urban Areas

B. Pikula[1]

[1]Department for IC Engines and Vehicles, Faculty of Mechanical Engineering Sarajevo,
University of Sarajevo, Bosnia and Herzegovina

Abstract

One of the most important objectives in the field of transport, especially in the urban areas, is reduction of fuel consumption and CO_2 emission, as well as other harmful pollutants emissions. There are lots of examples of new technologies, applied to conventional motor vehicles, which help achieving this objective. However, a very challenging plan for 2030 – EU urban city areas with zero emission vehicles, will be possible to achieve only by the electric vehicles use. Today, there are significant number of hybrid vehicles and almost negligible number of electric vehicles as visionaries of the future. Besides the all plans for the future, this paper has an aim to promote hybrid and electric vehicles as transport means with reduced pollutants emissions, fuel consumption and transport costs, already today. The analysis of fuel consumption, based on the recorded mass air flow (MAF), shows the significant reduction of fuel consumption in case of the hybrid vehicle use. An example of the electric vehicle use with zero emissions drive, as well as a model for calculation of transport costs based on the consumed energy is presented in the paper.

Keywords:
hybrid, electric, vehicle, emission, city

1 INTRODUCTION

Since 1990s, the most important objective in the field of transport has been a reduction of pollutants emissions from motor vehicles. It was a long term objective in order to achieve very low and almost zero emissions from motor vehicles in first decades of this century. Finally, the very challenging plan for 2030 is the EU cities with just zero emission vehicles.

It is well known that hybrid and electric vehicles can reduce pollutants emissions [1], [2] and [3]. Today, there are significant number of hybrid vehicles and almost negligible number of electric vehicles [4]. This paper has an aim to confirm justification of hybrid and electric vehicles use in urban areas through reduction of pollutants emissions, especially of CO_2 and fuel consumption. For this purpose, an analysis of one conventional motor vehicle and one hybrid vehicle is done. A special attention is dedicated to test drives in urban areas during traffic jams and without traffic jams. Also, a possibility of hybrid vehicle use as only electric vehicle is presented in the paper too.

2 URBAN DRIVING CYCLES

In order to carry out an analysis, recording of the vehicle driving cycles were carried with the conventional motor (Toyota Avensis 1.8) and hybrid (Toyota Prius 1.8) vehicles in urban conditions on a selected test run with the length of about 7.5 km in the city of Sarajevo, which is shown in the Figure 1.

Figure 1: Satellite view on the test run in urban area (City of Sarajevo).

Driving cycles of both vehicles were taken for the working and non-working day in same time period of day. Driving cycles of conventional motor and hybrid vehicles for the vehicles runs during the weekend, i.e. without traffic jams, are shown in the Figure 2, while for the case of the vehicles runs during the weekdays during the morning traffic jams are shown in the Figure 3.

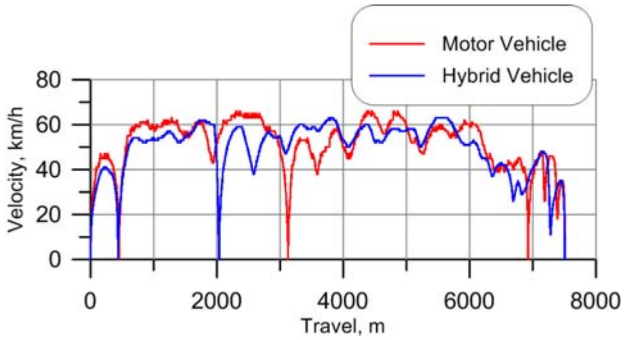


Figure 2: Test runs without traffic jams.

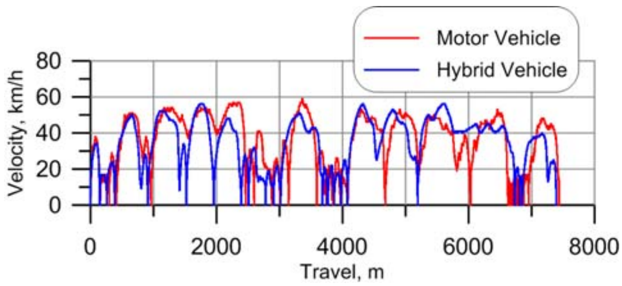


Figure 3: Test runs with traffic jams.

In the case of the motor vehicle drive on the selected test run without the morning traffic jam (red line in the Figure 2), the time spent was 620.46 s with the achieved average speed of 43.68 km/h. Under the same driving conditions, the hybrid vehicle (blue line in the Figure 2) needed 651.65 s for the same test run with the achieved average speed of 41.24 km/h.

After examining the results in the Figure 3, it can be seen that large number of stops at traffic lights were registered, as well as 4 periods with frequent starting and stopping of the vehicle. All this has caused that the conventional vehicle had spent 1600.13 s with the achieved average speed of 16.59 km/h, while the hybrid vehicle had spent time of 1440.09 s with the average speed of 17.89 km/h.

Although recording of each driving cycle can cause getting different results, these cycles are intended to show a random pattern that will be used for further analysis.

3 ANALYSIS OF CHARACTERISTIC PARAMETERS

In order to capture the characteristic cycles of the vehicle drive, along with a recording of many parameters of engines and vehicles, such as engine speed, mass air flow (MAF), the battery charge status of hybrid vehicles, etc. the Dash DAQ device II was used, as shown in the Figure 4.

Figure 4: Dash Daq II and its position in the Prius

The Figure 5 presents the characteristic parameters (velocity, Engine speed and mass air flow - MAF) during the conventional motor vehicle drive (Toyota Avensis 1.8) with the morning traffic jams in urban conditions.

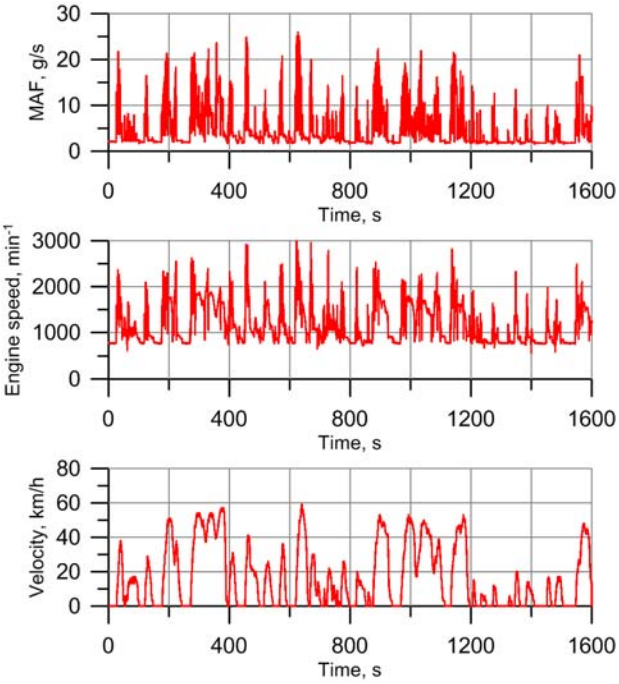


Figure 5: Motor vehicle during drive with traffic jams.

Based on the results related to the engine speed, it can be concluded that the petrol engine is continuously working, and in stationary conditions it develops the engine speed 720-820 min^{-1} which causes to achieve the fuel consumption of 0.55 to 0.65 l/h. The current trend in the modern petrol and diesel engines is reflected in the use of new technology under the trade name "Blue Efficiency", where in the case of a stopped vehicle the engine stalls, and it re-starts in the case of pressing the clutch pedal and by shifting the gear in the first speed, where a driver is expressing a desire to move the vehicle again. Applying this technology enables the savings in fuel consumption and pollutant emissions.

The above mentioned "engine management" has become evident especially in hybrid vehicles, where in addition to the internal combustion engine as the power unit, there is also the electric motor as an additional drive unit which uses electricity from the batteries. Depending on the battery charge, the position of the accelerator pedal, resting stages or movement, "engine management" controls the distribution of torque obtained from the IC engines and the electric motor. This is best seen on the results from the Figure 6 that relates to IC engine speed during the hybrid vehicle drive (Toyota Prius 1.8) in the morning traffic jams in urban conditions.

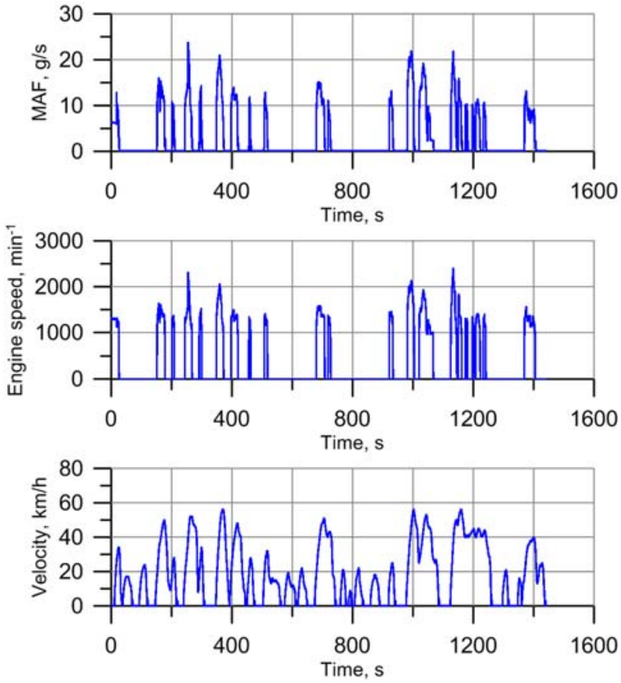


Figure 6: Hybrid vehicle during drive with traffic jams.

In order to analyze the functioning of the "engine management" system, a central part of the cycle is particularly singled out, which is shown in the Figure 7.

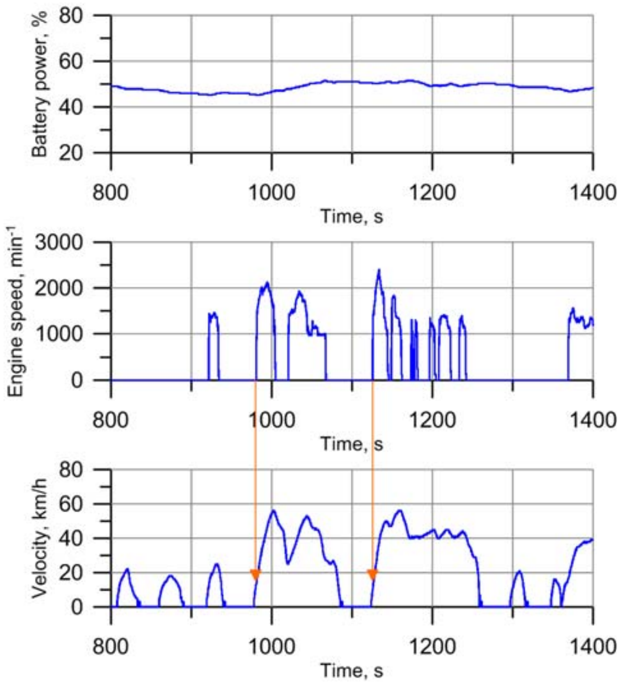


Figure 7: Segment of hybrid vehicle drive with traffic jams.

In the Figure 7 it is clearly seen that in the case of a frequent start-up of the hybrid vehicle from situ, achieving the vehicle speed up to 20 km/h, and stopping, the "engine management" engages only the electric motor. In doing so, it can be seen a gradual battery drain by reducing battery charge (Battery Power). With achieving the speed of over 20 km/h, the use of IC engine starts up as seen through the sudden increase in the engine speed indicated by the orange lines with the arrows in the Figure 7.

Certainly, the most important indicator for the driving cycle analysis conducted in the conventional engine and hybrid vehicles is the amount of fuel consumption. Since it is very difficult to determine the precise amount of fuel consumed without the use of modern measuring equipment, for the purposes of this analysis, the mass air flow (*MAF*) was used. Since in both cases, the conventional vehicle and the hybrid vehicle use a petrol IC engine and assuming that the coefficient of air/fuel ratio (λ) is constant and equal to 1, the mass flow rate of fuel (*MFF*) can be determined using the following expression:

$$MFF = \frac{MAF}{14.3\,\lambda}\,. \tag{1}$$

Knowing the fuel density ρ_f, hourly fuel consumption can be determined by using the following expression:

$$q = \frac{MFF}{\rho_f}\,, \tag{2}$$

i.e. the total fuel consumption by using the following expression:

$$Q = \int q dt\,. \tag{3}$$

Based on the previous expression, the typical indicators in terms of fuel consumption achieved in urban drives on the selected test run can be obtained, as shown in the Table 1.

Vehicle type	Used fuel (l) – calc.	Average fuel consumption (l/100 km) – calc.	Reduction (%)
Urban drive – no traffic jams			
Motor vehicle	0.506	6.733	0,00
Hybrid Vehicle	0.357	4.762	-29.27
Urban drive – with traffic jams			
Motor vehicle	0.744	10.01	0.00
Hybrid Vehicle	0.380	5.135	-48.65

Table 1: Analysis of fuel consumption

Based on the results shown in Table 1, it can be concluded that the fuel consumption in urban drive with and without traffic jams on the test run for the selected conventional motor vehicle is in the range of 6.733÷10 l/100km, while in the case of the hybrid vehicle is in the range of 4.762 ÷ 5.135 l/100km. If we take into account that the manufacturer data in conventional motor vehicles is 8.5 l/100km, and the hybrid vehicle is 4.0 l/100km, according to [5], it can be concluded that the calculations were done correctly.

Taking into account the results obtained, it can be concluded that the use of the hybrid vehicle in the urban conditions can contribute to significant savings in fuel consumption (25 ÷ 50 %) compared with the conventional motor vehicle (petrol), which depends on the form and the type of traffic jams.

4 ANALYSIS OF ELECTRIC VEHICLE DRIVE

Having in mind that no passenger electric vehicle was available, for the purpose of this analysis the hybrid vehicle Toyota Prius was used. This vehicle allows the use of electric drive solely in the case of a high battery charge. To show the feasibility of using electric vehicles in an urban city conditions, a segment of urban area was chosen as shown in the Figure 8.

Figure 8: Segment of urban area with traffic jams

The segment shown in the Figure 8 was chosen for a particular reason; as at the time of the analysis the flow of traffic was slow due to the construction works. The characteristic parameters such as velocity, speed of IC engine and battery charge during the vehicle motion on the adopted road segment are shown in the Figure 9.

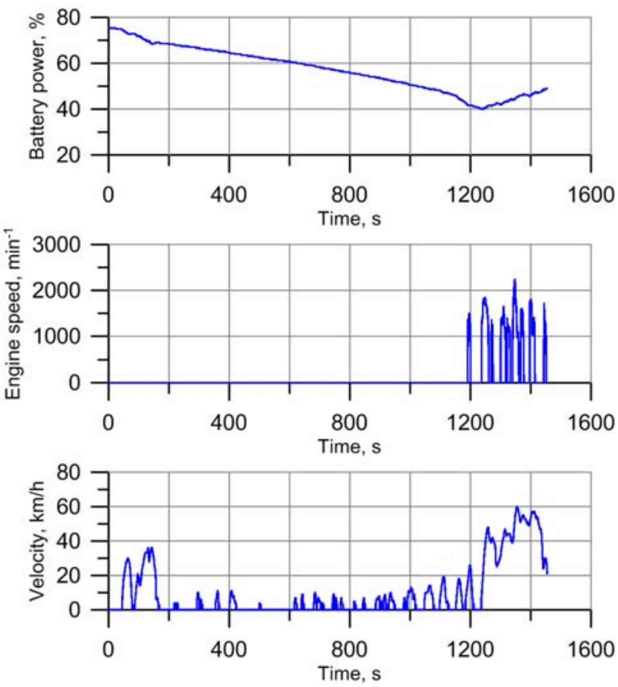


Figure 9: “Electric drive” during hybrid vehicle motion with traffic jams

In the Figure 9 it is clear that the first 1200 s of drive, on the section shorter than 2 km, is characterized with a prolonged stoppage and very low velocities of motion. For this case, the electric drive solely was used as it can be seen by the reduction of battery charge from 75 to 40 %, or zero of the IC engine speed. It is interesting to note that at a higher battery charge the vehicle can achieve the higher velocity of nearly 40 km/h, which was not true in the case of the results shown in the Figure 7, where the remaining battery charge was below 50 %. All this enabled to observe the motion of the hybrid vehicle as a motion of the electric vehicle with achievement of zero fuel consumption and zero pollutant emissions which are the basic characteristics of electric drives.

While in the case of the hybrid and conventional motor vehicle the analysis of fuel consumption could simply be performed based on the measurement parameters (mass air flow etc.), in the case of the electric and conventional motor vehicle this is not the case. The simplest method of analysis is the calculation of the cost of fuel and the cost of electricity for the same conditions of drive (for example, the same road segment in a given length, for example 100 km). However, the analysis can be conducted on the basis of a balance of energy consumed for the electric and conventional motor vehicle motion. Below is shown the mathematical model for calculating energy consumption.

In all driving conditions, a vehicle has to overpower road loads (resistances) that are defined through rolling and gradient loads (resistances) in the following form:

$$R_{road} = Gf \cos\alpha \pm G \sin\alpha \, , \tag{4}$$

where G – vehicle weight, f – rolling coefficient and α - climb angle. The following, always present, load (resistance) of motion is the air drag which depends on the drag coefficient, frontal area and velocity of motion.

$$R_{air} = \frac{1}{2} C_x \rho A v^2 \, . \tag{5}$$

Of particular importance for consumed energy, either through electrical or through fuel consumption is the load (resistance) of acceleration/deceleration:

$$R_{acc} = \pm\delta \frac{G}{g} j \, , \tag{6}$$

where δ - is coefficient of rotating masses and j - is acceleration or deceleration of vehicle. Based on the known values between motions loads (resistances), it can be determined the current power on drive wheels required for the vehicle motion movement.

$$P_w = \left(R_{road} + R_{air} \pm R_{acc} \right) v \, , \tag{7}$$

or energy required for this motion:

$$W = E = \int P_w dt \, . \tag{8}$$

It is important to note that for the conventional motor vehicle deceleration forces (R_{acc}) are converted into heat. On the other hand, the electric and hybrid vehicle deceleration forces can be used in the process called “regenerative braking” which can enable an increase in battery charge [2]. For gentle braking, up to 50 % of deceleration forces can be used to recharge the battery, whereas for the intense deceleration all the braking force is converted into heat. The biggest unknown for the accurate determination of the energy consumption of electric vehicles presents the process of regenerative braking, energy transformation and the achieved level of efficiency.

5 SUMMARY

Although modern automotive industry continuously works on implementation of new technologies that reduce pollutants emissions from modern conventional motor vehicles, the future of transport means, especially in urban areas belongs to the hybrid and electric vehicles. The paper presents an analysis of use of petrol operated conventional motor vehicle and hybrid vehicle during their motions in urban areas with and without traffic jams. The analysis was conducted in order to determinate fuel consumptions for both vehicles based on the recorded mass air flow (MAF). The results of the analysis show reduction of fuel consumption for 25 ÷ 50 %, depending on traffic flows, in case of hybrid vehicle use. A lower reduction of fuel consumption can be achieved in case of comparison between hybrid and diesel operated conventional motor vehicles, thanks to better engine management and the possibilities of electric drive use on start of vehicle motion.

Justification of electric vehicle use in urban areas is also shown in the paper. A simulated electric vehicle, during a test drive, produced the zero pollutants emissions. For further analysis, the model for calculation transportation costs based on the balance of consumed energy is developed and presented in the paper. A final result of transport costs can vary and it will depend on electric energy price and fuel price in any country or region.

6 ACKNOWLEDGMENTS

Author uses this opportunity to express his sincere thanks to Toyota Adria, Ltd. – Sarajevo, Bosnia and Herzegovina, who disposed mentioned vehicles for making analysis presented in the paper.

7 REFERENCES

[1] Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, 2004, *Modern electric, hybrid electric, and fuel cell vehicles: fundamentals, theory, and design, CRC Press.*

[2] Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, 2004, *Modern electric, hybrid electric, and fuel cell vehicles: fundamentals, theory, and design, second edition, CRC Press.*

[3] Fuhs, Allen E., 2007, *Hybrid vehicles and the future of personal transportation, CRC Press, 2007*

[4] International Energy Agency, 2010, *Technology Roadmap – Electric and plug-in hybrid electric vehicles,*

[5] www.toyota.ba – technical data

Public Faucets in Bosnia and Herzegovina

Ahmet Hadrović, PhD
Faculty of Architecture University of Sarajevo, Bosnia and Herzegovina

Abstract
In the life of the people of Bosnia and Herzegovina waters beyond the purely existential necessity. It is seen and treated as the most important God's gift to people and creatures, as the basis of life on which all verticals that define man. Aware of the fact that huge man is grateful to God for his generosity, and places where it seems particularly marked and treated as sacred places (pilgrimage sites). In Bosnia and Herzegovina is a lot of these places. Some places (shown in this paper) is rich with running water, while in other places (mostly on mountain slopes above the village) perform the prayer ("God sent supplications") that "God came down rain." Public fountains, especially as a functional and aesthetically arranged the meeting of man and the way water is especially important symbol of Bosnia and Herzegovina, through which one can read many dimensions of human personality and its collectivities in Bosnia and Herzegovina. Fountain encountered here in the open air (in the woods, mountain slopes, fields and fields ...), on the streets and squares of cities and villages, in courtyards of mosques and schools in the inner courtyards of individual home complex. It should be noted that for many people to such an extent built relationship with water as the basis of life that are simply racing to raise public fountain (*hair*) that will be of service to as many people. After the war (1992-1995), Bosnia and Herzegovina has raised a number of new drinking fountains in area of Sarajevo, and later in the whole of Bosnia and Herzegovina. Arrangements some of the fountains (not for its price but the immediacy of their intentions and messages) are both deeply personal and timeless, as highlight the best of the human essence. The author is in the last ten years has traveled throughout Bosnia and Herzegovina, personally "met the water" in its various forms and "symbiotic relationship with a man." Presentation of their experience and perception of water through this paper, the author remained in a conviction that Bosnia and Herzegovina and its people on their way the most sublimated essence that can not be undone even wars.

Keywords: God, water, life, Bosnia and Herzegovina.

1. HOLY PLACES ("pilgrimage sites")

In Bosnia, the Bosnians, living tradition of the cult of the water. This cult is manifested through ritual *dova*) in the . in ,). prayers) came down ." mountain peaks,). : good people" dervishes) in Blagaj , , Fig. 7.. , showering" , , sick" *Bjeljevine* ,). good people" dervishes), *Dobre vode* ,). prayers (open airSometimes the cult is manifested through the form of an extremely massive prayer that people would like to thank God for the gift of great leads (Ajvatovica PrusacFig. 2., 3.Sometime it comes to prayers (rainGod that He "to people and living things rain on the earthThese prayers are performed in an extremely attractive natural surroundings (usually near the medieval necropolisAnother way to perform prayer at the very sources of waterthe extremely generous sources raised the Tekke where "(and is often committed in particular to thank God for the gift of great leads (Tekkethe source of the Buna)Some times a person is in immediate contact with waterwhether it be "of water below the falls (as is the case with the *Svetinja* near BužimFig. 2., 5.), it is drink of the blazethat it touches or face washes or "a place on your body (in RudoFig. 2., 4.Sometimes it is a rich source of water associated with the legends of the "(whose righteousness has brought good to all people (near UstikolinaFig. 2., 6.

Fig. 1. Geographical location of Bosnia and Herzegovina

Fig. 2. Some of the holy places ("pilgrimage sites") in Bosnia and Herzegovina: Ajvatovica (1), Bjeljevine (2), Svetinja (3), Dobre vode (4).

Fig. 3. *Ajvatovica* near Prusac (mass showing of respect to the cult of water along with prayers and remembering of a good man, *Ajvaz-dedo)*

a)

b)

Fig. 4. *Bjeljevine* near Rudo (mass showing of respect to the cult of water)

a)

b)

Fig. 5. *Svetinja* near Bužim (mass showing of respect to the cult of water)

a)

b)

c)

d)

Fig. 6. *Dobre vode* near Ustikolina (mass showing of respect to the cult of water along with prayers and remembering of a good mans, *Šeh-Murat* (1737) and his son *Šeh-Salih*)

Fig. 7. Tekke in Blagaj (the source of the Buna river)

2. THE MEMORIAL FAUCETS BY THE ROADSIDE

According to Islam (as a belief and a general view of the world), death is not "missing" but only "relocation" of life on Earth in the "eternal world". As water is a symbol of life, and how to raise the fountain is one of the noblest works of man can do "in this world," raising the fountain in memory of those individuals who gave their lives to defend their honor and the reach the level of freedom of himself and the people who belongs - is the most direct, clearest and most sincere expression of respect for their sacrifice. Fountain with such purpose and symbolic messages were built in Bosnia and Herzegovina, especially after the 1992-1995 war (Fig. 8., 9.).

a)

b)

c)

d)

Fig. 8. Memorial faucet erected in honor of Bosnian Shahids *(1992-1995)* in Hrenovica near Goražde

a)

b)

Fig. 9. Memorial faucet erected in honor of Bosnian Shahids *(1992-1995)* in Vehabi near Kakanj

2. PUBLIC FAUCETS IN THE VILLAGES

Public Faucets in the villages had a fundamental existential basis in the villages. In fact, the village in Bosnia and Herzegovina are also emerging in the immediate vicinity of the persistent sources. Public Faucets supplied water to the villages and people and their pets. However, a public fountain and a lot more than that: it is a gathering place for people (especially young people, where it usually gives rise to love), where there is "something to see and learn, and to be seen" (Fig. 10., 11., 12., 13., 14., 15.).

Fig. 10. Water spring, *faucet* and watering place for animals (*Gornja voda*, Hadre)

Fig. 11. Public faucet in Bukov do (Olovo)

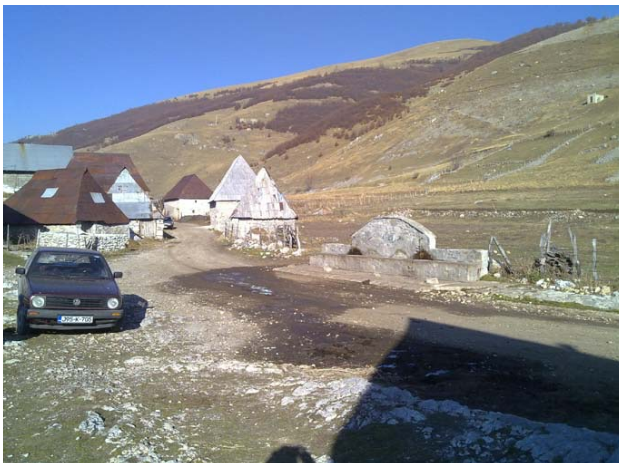


Fig. 12. Public faucet in Lukomir (Konjic)

Fig. 13. Public faucet in Petrovići (Olovo)

Fig. 14. Public faucet in Gornji Umoljani (Bjelašnica plateau)

Fig. 15. Public faucet in Sinanovići (Bjelašnica plateau)

3. FAUCETS AS THE GOOD WORKS OF INDIVIDUALS, AT VARIOUS

According to Islam, one of the nicest features is the God of his mercy and generosity toward people. Bosnians believe that their generosity towards others is the surest way to "draw closer to God," to be "chosen people whom God will grant good in this world and the next." Raising the drinking fountain with a steady, clean, healthy water is especially good work man. The work is all the greater if the water from the tap to use as many people. These tap-good works (*hair*is done with the roads (in the streets and squares of cities and villages (in the courtyards of mosques and schoolsto any place in nature and the built environmentwhere they can be the benefit of people.) Fig. 18., 19., 20., 21.), Fig. 16., 17.)

Fig. 16. Hafizadić Faucet in Jajce (1845-1846)

Fig. 17. Public Faucet in Livno

Fig. 18. Public Faucet in Pervizi (Bjelašnica Platau)

Fig. 19. *Hair-česma of Hadži-Sulejmana Hošić* along the road Igman-Šabići, Bjelašnica, 1975

Fig. 20. *Hair-česma* along the Šabići-Umoljani road (Bjelašnica plateau)

Fig. 21. Public faucet along the Ljubina-Korita road, near Sarajevo

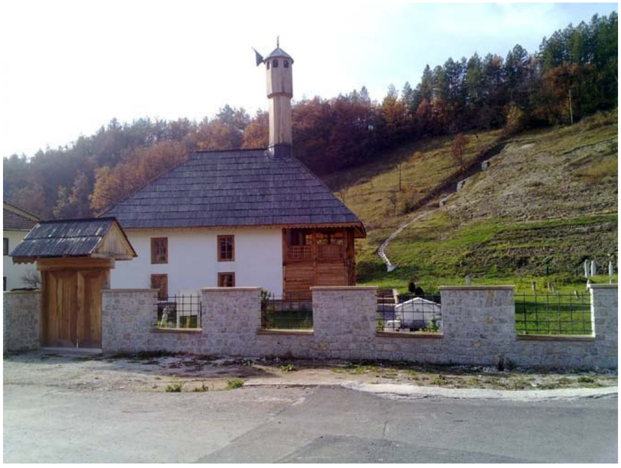


Fig. 22. Faucet in the harem of a El Fatih mosque (1463), Kraljeva Sutjeska

Fig. 23. Faucet in the harem of mosque in Golinjevo near Tomislavgrad

CONCLUSION

Water is a basic prerequisite of life. In Bosnia and Herzegovina people (as individuals and as collectivities of various types) have developed a cult led by expressing any public events (mass rallies and prayer) was an intimate, individual feelings and beliefs, which is basically every human activity-individual. Thus developed a relationship of respect toward the water will have far reaching positive effects on the conservation of water as a basic resourceAspects of water protection extends to all spheres of human life and its collectivityscience to practical action, the level of strategic planning to everyday lifeIn doing so, we are aware of the fact that Bosnia and Herzegovina little "of planet Earththat all the good that this is only part overall of planetary process. , from . piece" , of .

REFERENCES

a) Books:

1. Hadrović, A., *Gradska kuća orijentalnog tipa u Bosni i Hercegovini*, Sarajevo, Avicena, (1993, Prvo izdanje, 1995, Drugo izdanje),
2. Hadrović, A., *Defining Architecrural Space on the Model of the Oriental Style City House in Bosnia and Herzegovina, Serbia, Montenegro, Kosovo and Macedonia*, Booksurge, LLC, North Charleston, SC, USA, 2007,
3. Hadrović, A., *Bioclimatic Architecture, Searching for a Path to Heaven*, Booksurge, LLC, North Charleston, SC, USA, 2008.
4. Hadrović, A., *Hadre, The Evolution of Bioclimatic Architecture,* Booksurge, LLC, North Charleston, SC, USA, 2009.
5. Hadrović, A., *Research study on Architecture and Overview of the Architect's Experience*, Sarajevo, Acta Architectonica et Urbanistica, Arhitektonski fakultet u Sarajevu, 2010.,
6. Hadrović, A., *Architectura in Context*, Sarajevo, Acta Architectonica et Urbanistica, Arhitektonski fakultet u Sarajevu, 2011.,
7. Hadrović, A., *The Kozica river valley: sustainable living,* Sarajevo, Acta Architectonica et Urbanistica, Arhitektonski fakultet u Sarajevu, 2011.

b) Monographs:

1. Hadrović, A., *Očevijski majdani, juče, danas, sutra*, Sarajevo, Naše starine (Godišnjak Zavoda za zaštitu kulturno-istorijskog i prirodnog nasljeđa Bosne i Hercegovine, XVIII-XIX, 1989.
2. Hadrović, A., *Iz naših mahala i avlija, Sarajevo*, Avicena, 1993,
3. Hadrović, A., *Bosnom kroz gradove, Sarajevo,* (objavljena u vidu feljtona u listu *„Istina BiH“*), 1992-1995.

Analysis of Ecological Benefits of Urban Cycling in Sarajevo

D. Margeta
Public Company «Highways Authority of Federation of Bosnia and Herzegovina»
Bosnia and Herzegovina

Abstract
Paper treats comparative analysis of environmental benefits of using bicycles as a mean of urban transportation with zero emissions of pollutants and greenhouse gases. Analysis is presented by comparing emissions from transportation by passenger car or public transport modes. The paper also treats encouraging the citizens of Sarajevo to greater use of bicycles as a mean of transportation in case of adequate bicycle parking at the site of their work is available. The subject of the analysis are transport habits of 18 employees of Public Broadcasting Service of Bosnia and Herzegovina (BHRT), which are taken as an example to present ecological benefits of urban cycling compared to other means of transportaion.

Keywords:
calculating the emissions, urban cycling, emissions from public transportation and passenger car

1 INTRODUCTION

Urban cycling in Sarajevo is continuously expanding in recent years in spite of a evident lack of designated bike facilities that are primarily bicycle paths, tracks and the parking capacity to store bicycles which are usually bicycle racks of different categories. However, despite the rising trend, a serious studies of urban cycling in Sarajevo are very rare and therefore can not be precisely determine the transport potential for the transport of bicycles in the city, as well as the positive environmental impacts that mass use of the bicycle would have in Sarajevo. However, this paper will attempt, at least partially, to explain the positive environmental aspects of urban cycling.

The aim of this paper is twofold. The primary goal of research is to show real savings in greenhouse gases and pollutants in the real-world example in Sarajevo on the actual set of Moving observer at the actual location. A secondary goal is to demonstrate that properly located and technically well-chosen bike racks can act as a sort of generator for using a bicycles as a means of transport for daily commuting to work. Urban cycling generates savings in emissions of greenhouse gases and other pollutants which are inevedable byproduct of vehicles with internal combustion engines.

2 DESCRIPTION OF THE STUDY AND THE RESULTS

It has already been noted that a growing number of citizens of Sarajevo prefer bicycle as a mean of transport to commute to work or school. For this reason, numerous individual companies or large government institutions and organizations set bike racks for their employees which are usually located in the yard of the company building. Such an example in Sarajevo is the Public Broadcasting Service of Bosnia and Herzegovina - BHRT which has about 600 employees and is studied in this paper. BHRT has set an improvised bike rack five years ago which was suffient parking space for the employees who were riding their bicycles to work back than. With the expansion of urban cycling and the availability of disposing bicycles in front of BHRT building, the number of employees commuting on bicycle has increased. Therefore, additional bike racks have been set up in order to meet the demand for proper parking space. Data obtained through interviews with employees revealed that nearly fifty employees of BHTV from all three work shifts use a bicycle to commute to work, and eightteen of them cycle to work and back on daily basis. Transportation habits of these eighteen employees, for which we will adopt the name **Moving observers** what is appropriate for traffic studies, will be used to demonstrate real savings in emissions by comparing the different types of transportation in the city.

Above all, BHRT building is easily accessible by any mean of transport: bicycle, means of public transportation: tram and bus, or by a private car. It is situated in Sarajevo`s biggest county Novi Grad, address: Boulevard Meše Selimovića 12. Named boulevard, along with parallel Zmaja od Bosne Street creates logical route for urban cyclers riding in direction from Baščaršija to Ilidža. Along these roads there are complementary tram railways and city motorway with numerous bus lines. Both tram and a bus station are in the vicinity of BHRT building.

Bike rack itself is of improvised construction and was made by employees themself. It is positioned at the main enterance to the building and therefore, it is under constant video and physical surveillance. It preserves bicycles from theft, vandalism and inclement weather. We can classify this bike rack as closed areas bike parking facility which is the bike parking of highest safety class [1]. This is very important from perspective of urban cyclist that commute on daily basis because they generally are reluctant to park their bicycles on technically poor-choosen and uncecured parking spaces. Consequently, they will commute less by bicycle if proper parking facilities are absent.

Figure 1. Bike rack in front of BHRT building

This paper will follow transport habits of eighteen Moving observers that commute to work and back everyday. It will compare enviromental impact of their everyday trips and it will present emissions if these trips were taken by means of public transportation or private car instead of by bicycle.

Their addresses are obtained through an interview, and a real trip distance from their homes to their workplace, which is BHRT building, is determined by using GPS navigation device and appropriate software. It is presumed that Moving observers were choosing the shortest routes in their travels. Therefore, the **home-to-workplace** distance is calculated by selecting this method of traveling on GPS navigation device. This distance is the trip distance that has been traveled by bicycle for each employee every day. However, the traveled distance is different if travelling by means of public transportation or by a private car. Unlike the bicycle that is door-to-door mean of transportation, every trip taken by public transportation or by private car starts and ends with walking [2]. There are always two walking distances that have to be subtracted from actual trip distance determined by GPS device. In case of travelling by public transportation, we will adopt start trip distance of 400 meters for each Moving observer in this research paper [3]. Second wakling trip distance is determined by measuring distance from bus or tram station to the BHRT building enterance and it equals 50 meters. Therefore, total walking trip of 450 meters will be subtracted from the actual trip distance for each BHRT employee. Also, walking distance will be subtracted from each trip possibly taken by a passenger car. Meanwhile, we will presume something shorter walking distance for trips taken by private car. Citizens of Sarajevo park their cars very close to their homes, in 100 meter radius or usually less. Moreover, there are parking spaces for cars near to BHRT building. They are as near as in 100 meter radius too. Finally, total walking distance to be subtracted from each trip taken by a private car is 200 meter. It is presumed that Moving observers use the same mean of transport for coming to and going from their workplace. Therefore, Table 1 shows trip values for basic direction **home-to-work** and returnig direction **work-to-home**.

Data on Moving observers (BHRT employees)	Home address	Home-to-work distance [km]	Individual daily trip [km]		
			By Bicycle	By means of Public Transportation (corrected trip distance)	By Private Car (corrected trip distance)
Employee 1	dr. Fetaha Bećirbegovića 23 - Novo Sarajevo	2,5	5	4,1	4,6
Employee 2	Gor. Velešići 90 - Novo Sarajevo	8,1	16,2	15,3	15,8
Employee 3	Čobanija 12 - Centar	6,6	13,2	12,3	12,8
Employee 4	Zagrebačka 24 - Novo Sarajevo	5,2	10,4	9,5	10
Employee 5	Aleja lipa 66 - Novo Sarajevo	4,5	9	8,1	8,6
Employee 6	M. pase Sokolovića 20 - Stari Grad	7,4	14,8	13,9	14,4
Employee 7	Franca Prešerna 4 - Novi Grad	3,1	6,2	5,3	5,8
Employee 8	Kasindolska 14 - Ilidža	3,8	7,6	6,7	7,2
Employee 9	Doglodi bb. - Novi Grad	5,3	10,6	9,7	10,2
Employee 10	Briješće brdo 33 - Novi Grad	4,5	9	8,1	8,6
Employee 11	Nerkeza Smailovića 3 - Novi Grad	1,45	2,9	2	2,5
Employee 12	Mis Irbina 4 - Centar	6,3	12,6	11,7	12,2
Employee 13	Džamijska 6 - Novo Sarajevo	3,7	7,4	6,5	7
Employee 14	Grbavička 42 - Novo Sarajevo	4,6	9,2	8,3	8,8
Employee 15	Trg Grada Pratoa 7 - Novi Grad	2,8	5,6	4,7	5,2
Employee 16	Grbavička 28 - Novo Sarajevo	4,8	9,6	8,7	9,2
Employee 17	Gornji Velešići 13 - Novo Sarajevo	7,5	15	14,1	14,6
Employee 18	Kaukčijna 36 - Novi Grad	8,9	17,8	16,9	17,4
Total daily trip [km]	-	91,05	182,1	165,9	174,9

Table 1. Data on Moving observers whose transport habits were analyzed in this paper

Correction factor for emissions also has to be applied. Here, age of a vehicle greatly influences the amount of greenhouse gasses or pollutants emitted. Average age for a passenger car in Bosnia and Herzegovina is 16 years [4]. Vehicles used by public transportation company are about the same age on average. Therefore, data for calculation of greenhouse gasses and pollutant emissions are adjusted to the actual situation in Bosnia and Herzegovina and they are shown in Table 2. This adjustment had to be made because emission calculation would not be caorrect if we took more recent data that suit more to newer car engines. Another presumtion is that vehicles of public transportation run on electricty produced in thermal plants which are very common in Bosnia and Herzegovina. Additionally, data presume emissions of a passenger car with a average european occupancy rate [5] and emissions from vehicles of public transportation in conditions of good occupancy.

g/pkm	CO_2	NO_x	RSP (particles)
Bus	76,99	0,87	0,107
Tram	46,57	0,21	0,007
Passenger car	213,92	1,25	0,029

Table 2. Emissions for each polluting mode of transportation per passenger-kilometer

Now, it is important to determine period of time or number of days in one calendar year which were favorable for commuting by bicycle. Weather is the key determining factor for commuting by bicycle. Climate of Sarajevo and its wider area are quite good for cycling. We can claim that analyzed Moving observers were able to commute by bicycles for minimum of 180 and maximum of 220 days during the one calendar year [6]. These two values and their arithmetic mean, which is 200 days per year, will be adopted in total emissions calculation from vehicles of public transportation and a passenger car.

	Mean of transportation and analyzed period of year (minimum – mean - maximum)											
	Bus			Tram			Passenger car			Bicycle		
Greenhouse gas or pollutant	180	200	220	180	200	220	180	200	220	180	200	220
CO_2 [t]	2,30	2,55	2,96	1,39	1,55	1,70	6,73	7,48	8,23	0	0	0
NO_X [kg]	25,98	28,87	31,75	6,27	6,97	7,66	39,35	43,73	48,10	0	0	0
PSP [kg]	3,20	3,55	3,91	0,21	0,23	0,26	0,91	1,01	1,12	0	0	0

Table 3. Summary of emissons for analyzed commuting habits of Moving observers during the analyzed period of year

Table 3 presents exact savings and emissions for each mode of transport for analyzed set of Moving observers. At the first glance one may consider them small and insignificant. However, we have to consider the following. Analyzed set of Moving observers consists of only BHRT employees for who we can be certain that commute by bicycle on daily basis. Moreover, BHRT is only one of the companies in Sarajevo that has set bicycle rack in front of their building. Therefore, we can claim that savings in emissons are signifficant.

3 CONCLUSION

Urban cycling and walking are the only ways of moving in city that don`t produce any negative impacts on the enviroment. This is of vast importance, especially in City of Sarajevo that encounters decrease in quality of its enviroment due to specific relief, growing rates of transport on city road network and usage of fosil fuels, especially the coal, for heating during the winnter.

Paper has shown the real savings in green house gasses and pollutants on the example of BHRT employees who commute to work and back to their homes by bicycle everyday. Presented results should be used in planning future bicycle parking facilities in Sarajevo. Responsible authorities, above all Kanton Sarajevo Ministry of Transport, should consider setting up technically well-chosen bicycle racks on attractive locations in the city. Consequently, this will meet the demand of urban cyclers for parking spaces and encourage even more citizens to use bicycle in everyday trips. This paper treats only ecological benefits of urban cycling, but we should only name few absolute benefits of this transpotation mode: low costs of transport, less traffic congestion on city`s road network, excellent effects on cyclers health and creation of very positive urbanism effect in the city. Example of BHRT clearly shows how individual companies can take a big rolle in encouraging higher rates of bicycle use by their employees only by providing technically well-chosen and secure bicyle parking facilities.

REFERENCES

[1] SC VTA, *Bicycle Technical Guidelines,* Santa Clara Valley Transportation Authority, USA, CA, 2007.

[2] OTAK, *Hawaii Pedestrian Master Plan and Toolbox, USA, Hawaii, 2005.*

[3] R, Daniels, C, Mulley, *Explaining walking distance to public transport: the dominance of public transport supply*, World Symposium on Transport and Land Use Research, Whistler Canada, July 2011,

[4] *Average Passenger Car Age in Bosnia is 16,34 Years Old* (http://www.bljesak.info/web/article.aspx?a=21f15f33-d147-420a-90bb-ea1b0aee4c6c&c=038f6326-2ed4-4b18-946d-638763899a91)

[5] EEA, *Occupancy Rates* (http://www,eea,europa,eu/publications/ENVISSUENo12/page029,html)

[6] A. Alikadić, *Final paper –Development planning of non-motorized transport in Kanton Sarajevo,Faculty of Transport and Communications Sarajevo,*Sarajevo 2007.

Understanding Human Behavior in Designing Building-Scale Sustainable Ecosystems

M. Hadzikadic[1]

[1]Department of Software and Information Systems, College of Computing and Informatics
University of North Carolina at Charlotte, United States of America

Abstract

Building-scale sustainable ecosystems are not just about materials, technologies, processes, and standards. They are about people as well. It is the behavior of people who inhabit such buildings that often determine whether a building will realize its potential for efficiency and sustainability. Understanding both the power of incentives and the prevalence of human biases is extremely important in nudging human behavior toward sustainability and efficiency of their surroundings. This paper outlines the biases and possible incentives that may influence the ultimate efficiency and sustainability of the building.

Keywords:
Behavior, Complexity, Systems, Center, Region

1 INTRODUCTION

Due to evolutionary pressures, humans have developed certain traits that are expressed in the make-up of the social, cultural, political, and economic systems in which they participate. These traits have been analyzed and abstracted in theories as general as Maslow's hierarchy of needs [1] and as specific as Thaler and Sunstein's theory of "nudge" [2]. All of such theories recognize, either explicitly or implicitly, the power of incentives in understanding human behavior. When misguided incentives are combined with various kinds of human cognitive biases, then it is plausible that the resulting systems have suboptimal performance.

This paper outlines some of the relevant cognitive biases and plausible incentives that might prove to be beneficial in helping architects and engineers to nudge building occupants toward behavior that maximizes the potential of buildings for their long-term efficiency, usability, and sustainability.

2 COGNITIVE BIASES

As cognitive biases affect various aspects of human behavior, we will divide them into three categories: decision-making, belief, and behavioral biases; social biases; and memory errors and biases. All the definitions have been copied from the en.wikipedia.org Web site [3].

2.1 Decision-Making, Belief, and Behavioral Biases

- Availability heuristic – estimating what is more likely by what is more available in memory, which is biased toward vivid, unusual, or emotionally charged examples.
- Availability cascade – a self-reinforcing process in which a collective belief gains more and more plausibility through its increasing repetition in public discourse (or "repeat something long enough and it will become true").
- Bandwagon effect – the tendency to do (or believe) things because many other people do (or believe) the same. Related to groupthink and herd behavior.
- Curse of knowledge – when knowledge of a topic diminishes one's ability to think about it from a less-informed perspective.
- Decoy effect – preferences change when there is a third option that is asymmetrically dominated
- Distinction bias – the tendency to view two options as more dissimilar when evaluating them simultaneously than when evaluating them separately.
- Empathy gap – the tendency to underestimate the influence or strength of feelings, in either oneself or others.
- Framing effect – drawing different conclusions from the same information, depending on how or by whom that information is presented.
- Hyperbolic discounting – the tendency for people to have a stronger preference for more immediate payoffs relative to later payoffs, where the tendency increases the closer to the present both payoffs are.
- Knowledge bias – the tendency of people to choose the option they know best rather than the best option.
- Mere exposure effect – the tendency to express undue liking for things merely because of familiarity with them.
- Negativity bias – the tendency to pay more attention and give more weight to negative than positive experiences or other kinds of information.
- Reactance – the urge to do the opposite of what someone wants you to do out of a need to resist a perceived attempt to constrain your freedom of choice.
- Rhyme as reason effect – rhyming statements are perceived as more truthful.
- Status quo bias – the tendency to like things to stay relatively the same.

2.2 Social Biases

- Egocentric bias – occurs when people claim more responsibility for themselves for the results of a joint action than an outside observer would.
- False consensus effect – the tendency for people to overestimate the degree to which others agree with them.
- Fundamental attribution error – the tendency for people to over-emphasize personality-based explanations for behaviors observed in others while under-emphasizing the role and power of situational influences on the same behavior.
- Illusory superiority – overestimating one's desirable qualities, and underestimating undesirable qualities, relative to other people. (Also known as "Lake Wobegon effect," "better-than-average effect," or "superiority bias").
- In-group bias – the tendency for people to give preferential treatment to others they perceive to be members of their own groups.
- Projection bias – the tendency to unconsciously assume that others (or one's future selves) share one's current emotional states, thoughts and values.
- System justification – the tendency to defend and bolster the status quo. Existing social, economic, and political arrangements tend to be preferred, and alternatives disparaged sometimes even at the expense of individual and collective self-interest. (See also status quo bias.)
- Ultimate attribution error – similar to the fundamental attribution error, in this error a person is likely to make an internal attribution to an entire group instead of the individuals within the group.

2.3 Memory Errors and Biases

- Google effect: the tendency to forget information that can be easily found online.
- Humor effect: humorous items are more easily remembered than non-humorous ones, which might be explained by the distinctiveness of humor, the increased cognitive processing time to understand the humor, or the emotional arousal caused by the humor.
- Illusion-of-truth effect: people are more likely to identify as true statements those they have previously heard (even if they cannot consciously remember having heard them), regardless of the actual validity of the statement. In other words, a person is more likely to believe a familiar statement than an unfamiliar one.
- List-length effect: a smaller percentage of items are remembered in a longer list, but as the length of the list increases, the absolute number of items remembered increases as well.
- Modality effect: memory recall is higher for the last items of a list when the list items were received via speech than when they were received via writing.
- Part-list cueing effect: being shown some items from a list makes it harder to retrieve the other items.
- Picture superiority effect: concepts are much more likely to be remembered experientially if they are presented in picture form than if they are presented in word form.
- Positivity effect: older adults favor positive over negative information in their memories.
- Primacy effect, recency effect, and serial position effect: items near the end of a list are the easiest to recall, followed by the items at the beginning of a list; items in the middle are the least likely to be remembered.
- Self-serving bias – perceiving oneself responsible for desirable outcomes but not responsible for undesirable ones.
- Von Restorff effect: that an item that sticks out is more likely to be remembered than other items.

2.4 Implications

How can these biases be taken advantage of to influence people to behave in a more desirable way, when it comes to sustainability of the buildings they live or work in? Some examples include:

- Providing feedback information throughout the building, for example via displays, on the past and current sustainability-related measurements and indicators.
- Utilization of images and visualizations whenever possible in presenting such indicators and measurements.
- Presenting information using list of certain length, possibly placing the most important information last.
- Presenting information in a humorous way in order to encourage retention.
- Presenting relevant information at the level of business units in order to encourage positive competition towards common good.
- Presenting sustainability-related personalized information on smart phones.

3 INCENTIVES

When designing a building-scale sustainable “green” ecosystem, it is imperative that architects and engineers take into consideration: (a) patterns of tenant business and social activities, (b) their tendencies, biases, and preferences, and (c) the prevailing corporate/social culture in order to devise the most appropriate social and economic incentives to “nudge” people into doing “the right thing,” as defined by the current understanding of the utility/efficacy of the building/system and its participants. Such incentives might be provided in many forms, including:

- Group and individualized performance feedback. For example, it might be useful to provide information on energy preserving activities at both group and individual levels, as well as providing competition-inducing information on performance of teams deemed to be sustainability “champions.
- Awards for individual and group achievements for activities that promote sustainability,
- Lighting systems that induce positive emotions,
- Stimulating creativity through soliciting and rewarding novel ideas for sustainable work/living space,
- Designing spaces that promote establishment of social connections and system-enhancing norms,
- Promoting the use of “building social media” in creating the sense of identity for the building as a system.
- Devising mobile social-media applications that allow for both sustainability-related information gathering and support for organization of group-based sustainability activities.

4 TECHNOLOGY

In order to understand how human interactions, biases, and incentives work together to produce a particular behavior in a specific building, one must recreate such an environment and corresponding situations. Clearly, this is impossible in real life. The closest thing to it is a computer simulation. The theory of Complex Adaptive Systems (CAS) and the Agent-Based Modeling (ABM) technique are good candidates for a simulation method than can help architects, engineers, anthropologists, psychologists, and organizational specialists to understand and anticipate how a group of people will interact with the space and each other.

There are many examples where CAS and ABM techniques combined to offer a glimpse of possible solutions in complex life situations spanning domains of economic crises, political conflict, war, cancer, epidemics, traffic congestions, pricing, and ecology, to name a few. The author of this paper has participated in such experiments as well [4-8].

Complex systems are systems that exhibit some kind of a phase transition, where things suddenly take off. Examples include the onset of cancer, economic crises or war. These systems are often referred to as non-linear systems, indicating that the growth in the system is uneven over time. Systems whose components can adapt to changes in their environment are called Complex Adaptive Systems. Often the systems themselves can be adaptive as well.

One of the defining characteristics of complex systems is that they cannot be understood by reducing them to their constituent elements. This is because it is the interactions among those elements that define the aggregate properties of the system. This phenomenon is also described with the saying “the whole is greater than the sum of its parts.”

The ABM provides the method for simulating complex systems. The elements of such systems are represented as agents, where each agent has certain properties and rules of behavior. The environment in which agents operate provides the world in which agents exist and interact. Of course, agents can interact with the environment as well. These environments can be either open or closed, indicating the fact that they can either exchange energy with the surrounding systems or be self-contained. Finally, such systems have a fitness function, indicating that there is some measure of success with respect to a goal/purpose/outcome of interest.

In the case of designing sustainable buildings, the simulation environment represents the building itself. The agents are the building inhabitants. Their properties reflect their biases. The rules of behavior capture their biases, motivations, and preferences. The environment offers the mechanism for evaluating various incentive strategies. Finally, the fitness function offers the way for measuring their effect on the system itself.

5 SARAJEVO CENTER OF EXCELLENCE

Combining the efforts to design a building, anticipate the tenants’ behavior, suggest possible incentives, and evaluate the effect of putting in practice such incentives will require an interdisciplinary team of architects, sociologists, anthropologists, designers, psychologists, economists, and computer scientists who will jointly devise simulations of both tenant interactions and their use of space in order to design the most appropriate building for its intended use. Given that such interdisciplinary teams must be carefully structured, nurtured, and supported, we are recommending that a regional center of excellence, dedicated to understanding human behavior in designing building-scale sustainable ecosystems, be established in Sarajevo.

Putting together such a comprehensive sustainability center of excellence requires careful planning, broad and diverse expertise, sufficient space, adequate equipment, thoughtful and visionary leadership, political support, and sufficient funding.

Bosnia-Herzegovina and Sarajevo are the right place for it because of: a) their need for industries of the future that will help re-build the infrastructure of a war-torn country, b) their access to dedicated professionals who are returning to their home country after receiving their education at some of the best universities in the world, c) the enthusiasm and strong desire of young people to make a difference in a society where precious few things are proving to have actually worked in the past, d) the need to use this effort as a way to demonstrate to the divisive political powers that professionals and students can work together for the common good, regardless of their national and religious affiliations, e) the existence of buildings that reflect influences of so many different cultures that left their traces in this amalgam that is known today as Bosnia-Herzegovina, and f) the presence of relatively inexpensive infrastructure and work force.

Furthermore, such a center would prove invaluable in the country’s effort to revitalize and modernize its higher-education system, as well as its research and development initiatives and facilities. Consequently, it would be hard to find another place in the world where such a center would provide so many benefits for the required level of investment.

6 SUMMARY

This paper argues for better understanding of the importance of anticipating tenants’ behavior in the process of designing sustainable buildings. No matter how thoughtfully designed a building is, people can, and often do, find a way to defeat the best intentions of architects and engineers. Computer simulation techniques like CAS and ABM offer the possibility for making the necessary design decisions and adjustments even before the building is built.

7 REFERENCES

[1] Maslow, A.H., A Theory of Human Motivation, Psychological Review, 50, 370-396, 1943.

[2] Thaler, R.H., Cass R. Sunstein, C.R., Nudge: Improving Decisions About Health, Wealth and Happiness; Caravan Books, 2008.

[3] en.wikipedia.org.

[4] Hadzikadic, M., Carmichael, T., and Curtin, C., “Complex Adaptive Systems and Game Theory: An Unlikely Union,” Complexity Journal, November 2010.

[5] Khouja, M., Hadzikadic, M., & Zaffar, M., “An agent-based modeling approach for determining optimal price-rebate schemes,” Simulation Modeling Practice and Theory Journal, vol. 16, No. 1, pp. 111-126, 2008.

[6] Khouja, M., Hadzikadic, M., Rajagopalan, H., and Tsay, L., “Applications of Agent-Based Modeling to Pricing of Reproducible Information Goods,” Decision Support Systems Journal, vol. 44, issue 3, pages 725-739, February 2008.

[7] Dréau, D., Stanimirov, D., Carmichael T., Hadzikadic M., "An Agent-Based Model of Solid Tumor Progression," 1st International Conference on Bioinformatics and Computational Biology, 8-10 April 2009, New Orleans.

[8] Whitmeyer, J., Carmichael, T., Eichelberger, C., Hadzikadic, M., Khouja, M., Saric, A., Sun, M. "A Computer Simulation Laboratory for Social

Theories," the 2008 IEEE/WIC/ACM International Conference on Intelligence Agent Technology, Sydney, Australia, December 2008.

JERUSALEM: THE HOLY SITES - CULTURAL TRANSFORMATION AND CONTINUITY

Gil Peled,
University of Twente*, The Netherlands

Abstract

Cultural continuity is one of the key aspects of sustainable cities and settlements. Jerusalem is a city whose continuity relies primarily on the preservation of its holy sites and the cultures around it. However, every century brings new requirements and lifestyles which have an impact on the physical organization of the sites. The main question is how transformation processes of the Holy Sites can be guided in order to meet the requirements of today while preserving the essence of the holy sites for tomorrow. Jerusalem is cradle and sanctuary to the three major faiths. Throughout a turbulent 3000 year history, major sites of veneration have emerged from numerous transitions and transformations of sacred buildings and spaces in the city. This process has created a unique phenomenon of religious and cultural continuity often transcending politics and planning. These sites are now facing social and environmental challenges such as mounting pressures by mass tourism and pilgrimage, increased cultural and ethnic diversity, ageing structures and more. To ensure their continuity and to safeguard them for future generations, further understanding of these issues is vital. Focusing on the Holy Sites within the Old City, the paper and presentation will identify, in brief, their physical and virtual transformations, and the processes which generated them. It will then outline proposals for ensuring their cultural continuity and sustainable enhancement in the future.
** Based on a PhD research thesis being carried out under the supervision and guidance of* Associate Prof. Dr. Elma Durmisevic, University of Twente, The Netherlands.

Keywords:

Jerusalem, Holy Sites, cultural continuity, tangible, intangible, heritage, transformation, sustainability, future.

1 INTRODUCTION

1.1 Definitions

Culture is concisely defined as the way of seeing, perceiving and believing. It is required for human survival and creates a sense of belonging. It enables self-actualization and patterning of behaviors and beliefs. (1) Culture is multi-faceted, including social organization, customs and traditions, languages, arts, architecture and literature, religion, forms of government and economic systems. Cultures are not static and are increasingly subject to evolution and change as a result of technological progress, environmental changes, innovation, mobility and diffusion. (2) Many of these components are manifested in the built environment and are particularly evident in the formation of sacred places worldwide, creating cultural heritage over time (3)

Cultural heritage is the legacy of tangible artifacts and intangible attributes of a group or society that are inherited from past generations, maintained in the present and bestowed for the benefit of future generations. Cultural heritage includes tangible elements such as buildings, monuments, landscapes, books, works of art, and artifacts, and intangible elements such as folklore, traditions, language, and knowledge. (x) These elements have been recognized as fundamental for sustainable development. (x) The relation between tangible and intangible heritage can be summed up briefly as two sides of the same coin. (10) i.e. that there is an interdependency between the tangible and intangible, such as a space which is tangible created for ceremony which is intangible. Virtual cultural heritage relates to use of information and communication technologies and their application to cultural heritage, such as the reconstruction of buildings based on archaeological finds etc.

Cultural continuity is defined as the adaptations and changes to the patterns through which people structure their relations with one another, define common goals, and allocate resources. In the built environment this can be achieved by creating a heritage i.e. a meaning and function for the conserved place, so that it becomes understandable and imaginable to the general public (as well as the local one). Cultural continuity requires relating to historic, economic, cultural, social, and/or political contexts. (5)

Social cohesion relates to the bonds that bring people together in a given society. It is a multi-faceted discipline covering various social phenomena. To achieve social cohesion it is necessary to address issues of material conditions, tolerance, social exchanges and networks, inclusion of identities and values, ensuring equal opportunities and quality of life. Cultural continuity is a fundamental element for creating and enabling these conditions.

Sacred spaces / holy sites are sites where spiritual sensations and awe are evoked, where man encounters the numinous and the sublime. (3) These sites create a separation of the holy from the profane, heaven and earth, god and man. Sacred spaces may also be characterized by levels of sanctity i.e. a public area such as an altar for clergy, as well as the usage of non physical elements such as time and light. Many cultures devoted considerable resources to providing areas for cult, commemoration and pilgrimage. Religious and sacred spaces are among the most impressive and permanent buildings created by humanity, many are of Outstanding Universal Value such as the Holy Sites in Jerusalem. For a sacred/holy site to be recognized as of Outstanding Universal Value, it must also meet the standards set by UNESCO for integrity and/or authenticity and must have an adequate protection and management system to ensure its safeguarding (11)

The Holy Sites in Jerusalem form a unique inventory and composition of sacred sites of three major religions: Judaism, Christianity and Islam. There has been a long lasting physical and spiritual expression of sanctity in the city's appearance and it has always been a key element in its historical, cultural and architectural development, extending to present times. Two main sacred foci developed: the Temple Mount and the Church of the Holy Sepulchre, and an additional focus developed around the Western Wall. Noteworthy is the proximity, contest and tension between the sites, all of which contributed to their continuity. (x) Currently the Old City of Jerusalem and its Walls are on UNESCO's World Heritage in Danger list. (x)
Cultural continuity and sustainable development: Preservation of heritage and sustainable development are converging issues and are now widely acknowledged as such. Saving and prolonging lifecycles of existing buildings enables the strengthening of cultural fabrics, while reducing waste and environmental impact. Cultural heritage tourism enables regional economic development. Additional sustainable components include long-term land use, reuse of buildings and building material, and use of natural passive cooling and ventilation.

1.2 Focus

Cultural continuity is one of the key aspects of sustainable cities and settlements. Jerusalem is a city whose continuity relies primarily on the preservation of its Holy Sites and the cultures around it. However, every century brings new requirements and lifestyles which have an impact on the physical organization of the sites. The main question is how transformation processes of the holy sites can be guided in order to meet the requirements of today, while preserving the essence of the holy sites for tomorrow?

1.3 Methodology

The paper is based on previous as well as current research carried out by the author on the Old City of Jerusalem and focuses on three Holy Sites: the Temple Mount / Haram al-Shariff, the Church of the Holy Sepulchre, and the Western Wall and Hurva Synagogue. First, transformations, modes and types will be identified, based on historical accounts and archaeological findings, (6 ,7,12). Then, tangible and intangible aspects and patterns of cultural continuity of the Holy Sites will be investigated according to chosen elements of holy spaces. Based on investigation of past processes and patterns of transformation proposals will be outlined for ensuring future cultural continuity and sustainable enhancement.

2. TRANSFORMATIONS OF THE HOLY SITES (The Temple Mount / Haram, its perimeter)

2.1 Transformations

The thousands of years' long history of Jerusalem, its many layers, both physical and spiritual, as well as the vast amount of accumulated research and information, pose a challenge in any attempt to overview its numerous transition and transformations. In the following table and diagram, the transformations of the Temple Mount / Haram, the Church of the Holy Sepulchre, and the Western Wall and Hurva will be newly identified.

How Behavioral Science Can Help us Become More Green

N. Pistoljevic[1]
[1]Department of Health and Behavioral Studies, Teachers College
Columbia University at New York, United States of America

Abstract
Lots of discussion has been made about how to influence human behavior change towards preserving our planet and overall increasing peoples' Green Behaviors (GB). It is a problem that many different fields are trying to address without being familiar with the basic principles that drive the behavior change. Applied Behavior Analysis has produced a great deal of research and contributed to better understanding why people act the way they act and how to change that. This paper outlines some of the ways behavioral science can contribute to steering this over-exhausted world on its way to recovery and sustainability through systematically changing human behaviors using behavioral principles and evidence-based tactics and interventions.

Keywords:
Human behavior, green behaviors, applied behavior analysis, behavioral change, tactics

1 INTRODUCTION

By burning fossil fuels, deforestation, and engaging in other environment-impacting activities, we have offset the heat balance of earth so much that the global average temperature has moved outside the range that has characterized the 10,000 years of recorded human history [1]. This global warming is creating climate change with many collateral affects on our planet (e.g. rise of sea level, polar ice and glaciers melting, changes in precipitation patterns, changes in the species habitats and the boundaries of ecosystems, acidification of the oceans, etc.,), which in turn raise a risk for all life on planet, including human life [2],[3].

Climate change is a common problem for every part of the world, because the common human behaviors are the cause of it and what continues to contribute to it. These behaviors produce short-term gains or benefits for an individual and small groups vs. a long-term "common good" which cannot produce immediate and observable consequences to an individual. Like all choices we make, our decisions as consumers are more likely to be influenced by their short-term consequences for us as individuals (e.g. price, quality) rather than they are by their long-term consequences for society (e.g. environmental impact) [4].

Basically, all the scientists are convinced that the Earth is sick, and we all know that we gave it the disease [5]. Therefore, psychology as a science can contribute to the science of climate change in many ways from how people understand the causes of environmental problems, through understanding human consequences of climate change to designing socially significant behavior change programs that will affect the global warming phenomenon. The human behavior is in the centre of the problem; therefore the science of the human behavior needs to be at the core of the solution.

2 WHO AND WHAT CAN HELP?

There are many possible approaches to help improve the environmental problems: government policy, international conventions and declarations, educational programs, changing the curriculum in schools, technological innovations, raising public awareness, and so on. But, where do we start and how? This is a multidisciplinary problem, but with a human at a center of it, so maybe we should start with a detailed analysis and acquisition of better understanding of all the layers of a human mind and behavior.

2.1 Psychology and social sciences

Psychology and other social sciences can first help us identify what the common attitudes and beliefs about the global warming and climate change are in the world. With this baseline knowledge, we can then better understand where we stand and how to design the interventions to help people to help the planet. One such model for determining the baseline condition, the current state of mind, was developed by Maibach and colleagues in 2011 [6] when they conducted research to identify audience segments within the American adult population in order to consider them as potential targets for global warming public engagement campaigns. Audience segmentation is a process of identifying groups of people within a larger population based on their common critical attributes (e.g., beliefs, behaviors, political ideology) that are most relevant to the objectives one has. They identified six segments/groupings which all dramatically differed with regard to what they believes are about global warming and what they are actually doing about it. These six audience segments represent a spectrum of level of concern and actual behaviors about global warming, ranging from the Alarmed (18% of the population) who are the only ones doing something about it, to the Concerned (33%) who are just thinking about getting involved in some way, to Cautious (19%), then Disengaged (12%), to Doubtful (11%) who are not sure if there is such a thing as global warming, and finally to Dismissive (7%) who do not even believe that global warming is happening or that we should do anything about it [6]. With such data, social science researchers now know hot to better tailor the interventions in order to be able to affect the human beliefs and behaviors. With such vivid data that show such low percent of population in USA actually being aware and proactive about the pre-environmental change, it is clear that a big part of our anywhere in the world needs to still be raising public awareness and informing and educating the public.

2.2 Psychological Construct vs. Observable Behavior

Behaviors tied to environment protection and preservation or overall all "green behaviors" (GBs) are often in the literature referred to as pro-environmental behaviors, conservation behaviors, environmentally friendly behaviors, environmentally significant behaviors, environmentally sustainable behaviors, and/or responsible environmental behaviors [7], which seemed to refer to observable and measurable actions one can count, replace, increase, decrease, etc. But, when surveying the literature, one finds that most of research has actually focused discussion on psychological constructs, which is a concept used to describe specific psychological activity or a pattern of activity that is believed to occur or exist, but cannot be directly observed or measured. These constructs (e.g. believes, attitudes, values, influence, cognitive dissonance) are tied somehow to the "green behaviors", but unfortunately, not actual observable, measurable anything nor applied, useful, concrete information about how to actually change things. Many theories have also been developed and lots of research done focusing on surveys and self-reported behavioral outcomes, while data collection and analysis of actual countable behaviors have not been the choice for analysis. Mostly, research on GBs in psychology and social sciences are actually correlational reports, and through them numerous psychological constructs are identified and analyzed, so the literature focuses on : problem awareness, internal attribution, social norms, feelings of guilt, perceived behavioral control, attitudes, moral norms, intentions [8], [9], values, personality variables [10], identity processes [11], and there are many, many more. Treatments that included cognitive dissonance, perceived goal setting, social modeling, and prompts provided the overall largest effect sizes, but effective combinations of simple tactics directed at observable behaviors like making it easy to recycle, set goals for conserving gasoline, and model home energy conservation, have been successful at behavior change for decades and can be easily implemented and replicated across the world, and most important of all, everyone understands them. The problem with the correlational studies and the psychological constructs are that they are not providing the reader with the immediate "how to", and our planet has no time for just opinions, values, norms, attitudes, etc. We need to act now and we need to measure and observe what we are doing in order to have immediate feedback about the affect on the planet, so that we can make immediate changes and implement new tactics if necessary.

3 THING OR TWO WE AUGHT TO KNOW ABOUT HUMAN BEHAVIOR

Human behavior does not occur in vacuum, but in the environment, and also it is a product of its immediate environment. Behavior is dynamic, complex, variable and it is affected by the context in which it occurs. It is not a free-standing, independent phenomenon so we cannot examine and analyze it as such. Behaviors are function of ones genetic endowment, the material environment that surrounds us, and the social/cultural environment we live in. All these produce unique consequences, which in turn shape our behaviors, and make us who we are. Our environment causes us to select behaviors, and if those behaviors are successful, produce positive outcomes, we will act that way in the future too when found in the same or similar situation [12].

3.1 Few basic principles of human behavior

The science of behavior analysis for centuries has been identifying the basic principles of human behavior, answering the questions why we do what we do and how to change that. These basic principles are what we as scientists need to be aware of when designing interventions and tactics in order to affect the way individuals and populations behave. We need to be aware that human behaviors are strengthened or weakened by the consequences they produce, and that the behavior is largely a product of its immediate environment. Positive and negative reinforcement (adding desirable and removing undesirable stimuli) increases the behavior it follows later in the future, while positive and negative punishment (adding undesirable and removing desirable stimuli) decreases the behavior it follows in the future. Therefore, if you change the environment, (i.e. environmental consequences) you change the behavior. We also know that the most effective way to decrease any problem behavior is to actually increase compatible or replacement desirable behavior through positive reinforcement, as opposed to weakening undesirable behavior using aversive or negative processes. We respond much better to positive consequences and they produce more lasting and affective change. When found in an undesirable situation, we tend to emit avoidance behaviors whose function is just to delay the consequences. Therefore, the independent variables of primary importance to the behavior analysts are changes in the environment, that is, antecedent events that elicit, evoke, and cue behavior, and consequent events that select and maintain it. By systematically manipulating motivating operations, antecedents and consequences, using mostly positive reinforcement, we can produce lasting changes in the way all people behave.

3.2 More on why we do what we do

Also, we aught to know that although we all want to do the right thing, to help the environment and the planet, we put it off because we all have procrastinating behaviors developed, and there's no penalty for the delay [13]. in his article on procrastinating and putting things off when there is no clear deadline and punishment, Malott [13], talks about how a big part o the problem of "not saving the planet fast enough" are simply procrastinating behaviors and he concludes that we actually need tactics to combat those in order to increase appropriate GBs. Another interesting phenomenon we aught to pay attention to is that the contingencies set for a group are different from the contingencies for the individual. They are different in a way that they often are not effective in producing the desired behavior change [14]. It seems that the smaller the group, the more likely the contingency will affect behavior in the desired way and produce the change [15]. This tells us why when the government asks people to conserve water or use less electricity, only small portion of people actually comply, and these tactics are not as affective in producing the change.

4 APPLIED BEHAVIOR ANALYSIS

The very purpose of Applied Behavior Analysis (ABA) is to develop reliable evidence-based methodologies for improving socially significant behaviors [16], and today, is there any behavior more socially significant than the behavior that could save our planet? Therefore, ABA can and should offer the solutions for the current state of the world.

ABA is dealing with directly manipulating the environmental variables in order to produce learning (e.g. new repertoires in humans) and short-term or lasting behavior changes (e.g. improving/changing behaviors already in the repertoire). Behavioral evidence-based tactics (e.g. Rules, Praise, Ignoring; Token Economy, Peer Tutoring, Vicarious Reinforcement, Contingency Contracts, Positive Feedback, Self- Monitoring, Shaping, Fading, etc.) have been used since the 20’s and 30’s to produce favorable changes in human behaviors, so we should just simply continue applying the same successful methodologies in order to create and maintain more “green” society.

4.1 ABA and Green Behaviors (GBs)

Lots of research in ABA addressed the GBs improvements and showed great results as early as in the 70’s. The studies were done in litter and pollution control [17], [18], [19], recycling [20],[21], energy conservation [22], and on increasing bus ridership [23], [24]. Later, Nevin [25] reported of a town in USA where thinking about ways to reduce fossil-fuel use became competition. Energy independence without adding carbon dioxide to the atmosphere was the long-term goal, and the town meetings served for monitoring, motivating, providing reinforcement for short-term objectives all had set for themselves. Prichard [26] offered a solution to decrease CO2 emission by through a system of reinforcement by offering virtual rewards for people who drive “green”. On the other hand, Geller [27] offered behavioristic point of view for increasing environmental protection.

4.2 Small scale, low-cost behavior change for all

Stiil, I want to shed more light on are small-scale and/or low-cost concrete simple tactics to influence individuals’ behavior. For example, one can start by setting up individual long-term and braking them down to short-tem green goals to achieve, which is a behavioral tactic called “task analysis”. Then, one can set up “if-then” contingencies (Contingency Contract), keep track and measure advancement (Self-monitoring tactic), and attainment of the goals should function as reinforcement, which in turn will then maintain the behavior. If we added sharing our achievements at the building/street/school meetings, we are bringing another reinforcing variable, peers, which in turn will increase motivation and produce more reinforcement, and therefore maintenance of ones GBs. Though, whatever adults might accomplish on the GBs change front, any sustained success will require the help of the world’s more than 2.2 billion children [5], so we need to start teaching our youth to grow green. We need to improve our curricula at schools to include big segments about our planet, the state it is in, and what little every person can do to make a difference. A family can set up a contingency at home for all to collect points for all pre-selected GBs they emit (e.g. not showering for longer then 10 minutes, closing the faucet when brushing ones teeth, recycling properly, not buying new plastic bags, choosing to buy recycled items vs. regular ones, not buying any drinks in plastic bottles, using “scrap paper” to draw and color on, reusing objects in the house, etc.), and set up a monthly meeting and point exchange for preferred reinforcers (Token Economy tactic). Keller [21], as a 3rd grade student decided to increase recycling on his street, and provided weekly feedback to the neighbors, which in turn through reinforcing contingencies and peer pressure, increased recycling to 100% on his street. Such small behavioral changes can produce overall large affects on our environment.

5 SUMMARY

Research today mostly focuses on the major systematic application of behavioral tactics to affect the change on the largest scale possible. For example, government providing incentives as reinforcement for citizens installing solar panels or producing their own energy, governments reinforcing alternative travel patterns to decrease CO2 emission in their towns, states, countries, or punishing contingencies for people who do not recycle in order to increase recycling behavior of the communities, etc. Other majority of research focuses on the people’s attitudes towards green policy changes and social political campaigns toward conserving environment. But, most of the population is not in a position to directly influence government or corporate policy making, while on the other hand, all people consume materials and energy, and as such, each person can change behaviors that are comparatively better for the environment. Since humans created the problem with the physical environment (e.g. the planet) with their behaviors, the only way to fix the problem it is to change the behavior of the humans!

We have the evidence-based methodologies derived from behavioral science, the knowledge needed to set up motivating operation that will evoke such behaviors deemed as environment friendly and pro-environment. The science and technology to do so existed for decades, its time to start using them. It is the time to spread the word!

6 REFERENCES

[1] Intergovernmental Panel on Climate Change 2007, Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, & H. L. Miller, Eds.). New York, NY: Cambridge University Press.

[2] National Research Council. (2010). Advancing the Science of Climate Change. Washington, DC: National Academies Press.

[3] Swim, J. K., Stern, P.C., Doherty, T. J., Clayton, S., Reser, J. P., Weber, E. U., Gifford, R., Howard, G. S., 2011, Psychology's Contributions to Understanding and Addressing Global Climate Change, American Psychologist, Vol 66(4), 241-250.

[4] Layng, T. V. J., 2010, Buying Green, Journal of Applied Behavior Analysis, 33, 175-177.

[5] Heward, W. J., Chance, P., 2010, Introduction: Dealing With What Is, The Behavior Analyst, 33 (2), 145-151.

[6] Maibach, E. W., Leiserowitz, A., Roser-Renouf, C., Mertz, C. K., 2011, Identifying Like-Minded Audiences for Global Warming Public Engagement Campaigns: An Audience Segmentation Analysis and Tool Development, PLoS ONE 6(3): e17571. doi:10.1371/journal.pone.0017571.

[7] Osbaldistone, R., Schott, J. P., 2012, Environmental Sustainability and Behavioral Science: Meta-Analysis of Proenvironmental Behavior Experiments, Environment and Behavior, 44 (2), 257-299.

[8] Bamberg, S., Möser, G., 2007, Twenty Years after Hines, Hungerford, and Tomera: A new Meta-analysis of Psycho-social Determinants of Pro-environmental Behavior, Journal of Environmental Psychology, 27, 14-25.

[9] Hines, J. M., Hungerford,H. R.,Tomera, A. N., 1987, Analysis and Synthesis of Research on Responsible Environmental Behavior: A Meta-analysis. Journal of Environmental Education, 18, 1-8.

[10] Balderjahn, I., 1988, Personality Variables and Environmental Attitudes as Predictors of Ecologically Responsible Consumption Patterns. Journal of Business Research, 17, 51-56.

[11] Clayton, S., Opotow, S., 2003, Introduction: Identity and the Natural Environment. In S. Clayton & S. Opotow (Eds.), Identity and the Natural Environment: The Psychological Significance of Nature (pp. 1-24). Cambridge, MA: MIT.

[12] Skinner, B. F., 1981, Selection by Consequences, Science, 4507 (213), 501-504.

[13] Malott, R. W., 2010, I'll Save the World from Global Warming Tomorrow; Using Procrastination Management to Combat Global Warming, The Behavior Analyst, 33 (2), 179-180.

[14] Slavin, R. E., Wodarski, J. S., Blackburn, B. L., 1981, A Group Contingency for Electricity Conservation in Master-metered Apartments, Journal of Applied Behavior Analysis, 14, 357–363.

[15] Nevin, J. A. (2005). The Inertia of Affluence, Behavior and Social Issues, 14, 7–20.

[16] Copper, J. O., Heron, T. E., Heward, W. L. , 2007, Applied Behavior Analysis (2nd Ed.), Upper Saddle River, NJ: Pearson Education, Inc.

[17] Powers, R. B., Osborne, J. G., Anderson, E. G., 1973, Positive Reinforcement of Litter Removal in the Natural Environment, Journal of Applied Behavior Analysis, 6, 579–586.

[18] Clark, R. N., Burgess, R. L., Hendee, J. C., 1972, The Development of Anti-litter Behavior in a Forest Campground. Journal of Applied Behavior Analysis, 5, 1–51.

[19] Geller, E. S., Farris, J. C., Post, D. S., 1973, Prompting a Consumer Behavior for Pollution Control. Journal of Applied Behavior Analysis, 6, 367–376.

[20] Witmer, J. F., & Geller, E. S., 1976, Facilitating Paper Recycling: Effects of Prompts, Raffles, and Contests. Journal of Applied Behavior Analysis, 9, 315–322.

[21] Keller, J. J., 2010, The Recycling Solution: How I Increased Recycling on Dilworth Road, The Behavior Analyst, 33, 171–173.

[22] Winett, R. A., Hatcher, J. W., Fort, T. R., Leckliter, L. N., Love, S. Q., Riley, A. W., et al., 1982, The Effects of Videotape Modeling and Daily Feedback on residential electricity conservation, home Temperature and Humidity, Perceived Comfort, and Clothing Worn: Winter and Summer, Journal of Applied Behavior Analysis, 15, 381–402.

[23] Everett, P. B., 1973, The use of the Reinforcement Procedure to Increase Bus Ridership. Proceedings of the Annual Convention of the American Psychological Association, 897-898.

[24] Everett, P. B., Hayward, S. C., Meyers, A. W., 1974, The Effects of a Token Reinforcement Procedure on bus Ridership. Journal of Applied Behavior Analysis, 7, 1-9.

[25] Nevin, J. A., 2010, The Power of Cooperation, The Behavior Analyst, 33 (2), 189- 192.

[26] Pritchard, J., 2010, Virtual Rewards for Driving Green. The Behavior Analyst, 33, 185–187.

[27] Geller, E. S., 1990, Behavior Analysis and Environmental Protection: Where Have all the Fowers Gone? Journal of Applied Behavior Analysis, 23, 269–273

International Council
for Research and Innovation
in Building and Construction

CIB Mission

we focus on:
Construction and Society
we support:
international cooperation in research and innovation
for better buildings and a better built environment
we provide:
access to experts and information worldwide

CIB was established in 1953 with support of the United Nations and holds a UN Special Consultative Status

CIB Members and Benefits

Members are individuals, companies, institutes, agencies and other types of organizations who want to exchange information and collaborate in the area of research and innovation for building and construction. Their professional focus may be on programming or executing research, or on dissemination and application of outcomes from research. This includes people and organisations with a research, university, industry or government background.

Members have immediate access to the world's leading experts and expertise and are facilitated to present and validate their own knowledge and technology. They are also offered opportunities for collaboration in international projects. In these, leading experts bring state-of-the-art technologies together in support of continuous improvements of building and construction systems, processes and technologies all over the world.

CIB General Secretariat
Kruisplein 25-G
3014 DB Rotterdam
The Netherlands
Phone: +31-10-4110240
E-mail: secretariat@cibworld.nl
www.cibworld.nl

International Council
for Research and Innovation
in Building and Construction

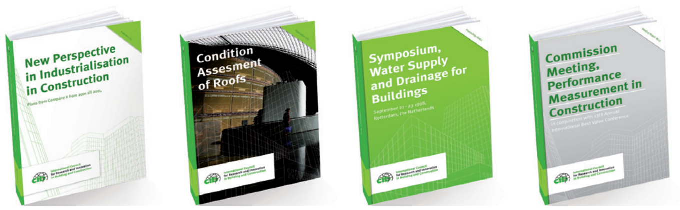
CIB Commissions

Members can choose to participate in a selection of over 50 Commissions in the areas of Building Techniques, Design of Building and the Built Environment, and Building Process.

Examples of recently established Commissions are:
TG82 Marketing in Construction
TG84 Construction Reform
TG85 R&D Investment and Impact
W118 Clients and Users in Construction
W119 Customized Industrial Construction

CIB Publications

International collaborative projects result in the publication of: conference proceedings, state of the art reports, best practice presentations, practitioners guidelines, pre-standardization documents, R&D Roadmaps etc.



Examples of recent CIB Publications are:
- Green Buildings and the Law
- Culture in International Construction
- New Perspectives in Industrialisation in Construction
- Usability of Workplaces

Membership Fees

Annual Fees depend on the type of Membership (Full, Asssociate or Individual) and on the type and size of the organization.

Fees in 2012:
Full member € 12195 or € 8131 or € 2797
Associate member € 1405 or € 1371
Individual member € 279

Discounts of 25% or 50% are offered to Members in countries with a GNIpc of less then USA $7000 or $1000 respectively.

www.cibworld.nl

CIB General Secretariat
Kruisplein 25G
3014 DB Rotterdam
The Netherlands
E-mail: secretariat@cibworld.nl
www.cibworld.nl

CIB Publication 366 / ISBN 978-90-365-3451-2